Complex project management: matching organisational problems and project management methodologies

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Organisations must adapt to their changing business environment to remain profitable, competitive and able to meet their strategic goals, with projects often the instruments used to do so. A project is a temporary endeavour aimed at creating a unique product or service, or at meeting a specific strategic objective, with Project Management (PM) the application of knowledge, skills, tools, and techniques to project activities to reach such an outcome. These are usually combined in specific PM methodologies, which may have a profound impact on project success. With organisational problems of increasing complexity and volatility, there is a growing recognition that better PM methodologies should be developed to deal with these characteristics, and that PM should be seen as a form of complex problem solving. This has led to an increase in hybrid PM approaches, with practitioners attempting to reap the benefits of combining the discipline of predictive PM methodologies with the flexibility of adaptive ones. However, both deep insights into such practices and methodological support for hybridisation are still lacking.
This context drives our research, whose overall aim is to investigate the relation between organisational problem characteristics and parametrisation of PM practices, and to establish the extent an existing problem solving framework, Problem Oriented Engineering (POE), with roots in design and engineering, may provide the theoretical and methodological basis for project parametrisation and more systematic hybridisation. We take a mixed method approach, including both secondary and primary research. Specifically, we conduct a literature analysis and a practitioner survey to propose a fine grain mapping between volatility and complexity dimensions of organisational problems and risk controls in predictive and adaptive PM methodologies, as a first step towards the systematisation of hybrid combinations in projects. Simultaneously, we develop our interpretation of PM processes and practices within the POE framework. Finally, by drawing our findings together, we propose a systematic approach for the parametrisation of PM processes in the face of complexity and volatility with the objective to better mitigate the risks arising from them, which we test and validate in two case studies. The outcomes of our research contribute both to knowledge and practice: we provide both an extension and novel application of POE to the PM discipline, and a systematic approach to project parametrisation, which may support project managers in their daily practice.
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<tr>
<td>A</td>
<td>Amber, which indicates weak mitigation</td>
</tr>
<tr>
<td>CHANGEENV</td>
<td>Rate of change in the external environment, such as legal regulations</td>
</tr>
<tr>
<td>CHANGESOC</td>
<td>Rate of change in the organisation</td>
</tr>
<tr>
<td>CHANGETEC</td>
<td>Rate of change in the technical solution</td>
</tr>
<tr>
<td>COMPLCOMM</td>
<td>Complicated communication due to organisational or technical characteristics</td>
</tr>
<tr>
<td>DAD</td>
<td>Disciplined agile delivery</td>
</tr>
<tr>
<td>DIVSOC</td>
<td>Diversity of stakeholder</td>
</tr>
<tr>
<td>FIXALL</td>
<td>Fixed scope, budget &amp; time</td>
</tr>
<tr>
<td>FIXSCOPE</td>
<td>Variability of time &amp; budget with fixed scope</td>
</tr>
<tr>
<td>G</td>
<td>Green, which indicates strong mitigation</td>
</tr>
<tr>
<td>HIGHRISK</td>
<td>High risk</td>
</tr>
<tr>
<td>KNOWLEGEST</td>
<td>Lack of pre-given knowledge at project start</td>
</tr>
<tr>
<td>MANPMOREQ</td>
<td>Management and/or PM office requirement</td>
</tr>
<tr>
<td>NOVELTEC</td>
<td>Novelty or uniqueness of the technical solution</td>
</tr>
<tr>
<td>NUMSOC</td>
<td>Large number of stakeholder or organisational units involved</td>
</tr>
<tr>
<td>NUMTEC</td>
<td>Large number of technologies or interfaces involved</td>
</tr>
<tr>
<td>PE</td>
<td>Problem Exploration</td>
</tr>
<tr>
<td>PM</td>
<td>Project Management or Project Manager</td>
</tr>
<tr>
<td>PMBOK</td>
<td>Project Management Body of Knowledge</td>
</tr>
<tr>
<td>PMI</td>
<td>Project Management Institute</td>
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<tr>
<td>POE</td>
<td>Problem Oriented Engineering</td>
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<tr>
<td>PPP</td>
<td>POE Process Pattern</td>
</tr>
<tr>
<td>RAG rating</td>
<td>Red, Amber and Green</td>
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<tr>
<td>R</td>
<td>Red, which indicates that the control should be avoided</td>
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SE                   Solution Exploration
TEAMEXP              High level of expertise in project team
UNCERGOAL            Uncertainty of goals, unclear meanings or stakeholder’ hidden agenda
URGENCY               Urgency or criticality of time goals
VARSCOPE             Variability of scope with fixed time & budget

Glossary of main terms used in this report

- Adaptive methodologies: PM methodologies characterised by their adaptability to change during the project life-cycle, also known as ‘agile’.

- Complexity: related to the presence of many interconnected parts, which may interact in complicated or unpredictable ways.

- Concept: in project management, “a mental construction meant to help solve a problem or satisfy a need” (Williams and Samset, 2010); same as ‘solution’.

- Domain: in POE, a set of related phenomena that are useful for problem analysis.

- Need: in POE, something that a solution must satisfy in a particular context.

- Phenomenon: in POE, any observable relevant to a problem.

- Predictive methodologies: PM methodologies characterised by fully planned rational processes, also known as ‘plan driven’ or ‘traditional’.

- Project scope: “the work content and products of a project or component of a project” (Stuckenbruck, 1981).

- Problem: in POE, a need in context.

- Problem diagram: in POE, a diagram showing the structure of a problem in terms of its domains, phenomena and need.

- Solution: in POE, an artefact that satisfies a need in context; in project management, same as ‘concept’.
• Stakeholders: individuals, groups or organisations who may affect, be affected by, or perceived themselves to be affected by a decision, activity or outcome of a project.

• The Iron Triangle: Cost, time and quality as the most commonly applied criteria to measure project success (Atkinson, 1999).

• Volatility: related to the likelihood of change.
To my children...
Chapter 1

Introduction

1.1 The research problem and its justification

The Project Management Institute (PMI), an international body aimed at bringing professionalism to the area of project management (Carton, Adam, and Sammon, 2008), sees projects as the instruments used by organisations to “help meet their strategic goals like meeting changes in market demands, customer requests, or organisational requirements and in this way adapt to the changing business environments” (Project Management Institute, 2013). In a context of heightened competition and ongoing technology, market and social disruption, organisations have recognised that real value and benefits can only be delivered if ideas can be translated into reality (Pulse of the Profession (2018)). Hence the strategic value of projects and programmes is becoming prominent, together with a recognition of the relationship between business success and appropriate project implementation (Project Management Institute, 2017b). In particular, the correlation between project success and choice of Project Management (PM) methodology has been evidenced in the literature: for instance, based on a large-scale survey, Joslin and Müller (2015) estimated that it accounts for 22.3% of the variation in project success, when measured against the overall project objectives.

In spite of the wide choice of PM methodologies available, projects still fail with severe consequences for the organisations. As recently reported by Project Management Institute (Pulse of the Profession (2020)), 11.4% of investment is wasted due to poor project performance, while a study conducted in 2013 (Böhle, Heidling, and Schoper, 2015) into
5,400 Information Systems projects, an important class of organisational projects, concluded that 50% of them either exceeded their planned budget before completion or addressed a reduced scope, while 20% even put the existence of the company at risk.

The reality is that the problems organisations face are becoming more complex and volatile, so that existing PM methodologies and practices are increasingly challenged, which may explain why project deviation or failure remain so common. As a result, some authors have proposed that project management should be regarded as a form of organisational problem solving (Ahern, Leavy, and Byrne, 2014), while practitioners are looking creatively at novel ways to combine known approaches and practices into hybrid methodologies (Theocharis et al., 2015) better suited to the nature of today’s organisational problems, with a growing trend to combine the discipline of predictive PM methodologies with the flexibility of adaptive ones (Boehm and Turner, 2004; Kuusinen et al., 2016).

Yet, an understanding of hybrid PM approaches and their adoption remains limited, with few studies focused primarily on software product development (which I describe in Chapter 2, Section 2.4.2), and their theoretical and methodological underpinning still lacking (Geraldi, Maylor, and Williams, 2011). Addressing this gap is the overarching aim of my research.

In my research I postulate that the choice of PM methodologies and practices, and the way projects are set up should be influenced directly by complexity and volatility characteristics of the organisational problems to be addressed. I also argue that an existing framework for complex problem solving, Problem Oriented Engineering (Hall and Rapanotti, 2017), with its roots in design and engineering, can provide the theoretical and methodological basis for systematic PM hybridisation and project parametrisation.

1.2 Research aim & methodology

The aim of this dissertation is to investigate the relation between organisational problem characteristics and the parametrisation of PM practices and to analyse how an existing problem solving approach, the Problem Oriented Engineering (POE) framework (Hall, Rapanotti, and Jackson, 2008; Hall and Rapanotti, 2015) can guide this parametrisation.
Chapter 1. Introduction

Specifically, the research aim will be tackled by answering the following research questions:

- **Q1: How can PM concepts be interpreted in POE?**
  
  To address this question, primary research is conducted in the form of a case study from the author’s professional practice, where POE is applied retrospectively to exemplify how complex project management can be interpreted as complex problem solving and to which extent POE can be used as a problem solving framework in such a context. This case study is supported by the review of the related academic literature and is the initial step for the design method applied to answer Q3.

- **Q2: which factors affect current choices of PM approaches made by practitioners in organisations?**
  
  The literature review on problem characteristics, risks and project methodologies is the starting point to answer this research question. Primary research, in form of a survey, is also conducted so that to identify which factors influence practitioners’ choice of PM approaches and to which extent these are related to problem characteristics of complexity and volatility.

- **Q3: How can PM processes be parametrised based on problem characteristics?**
  
  The design and creation research methodology is applied in order to design a problem oriented framework to parametrise PM processes. The case study applied to answer Q1 together with the practitioner survey set up to answer Q2 are the starting point to answer Q3. The proposed framework is validated through a second confirmatory case study also from the author’s professional practice, and a practitioner evaluation in form of online interviews.

In summary, in this work I follow a mixed-method approach.

Firstly, I analyse the literature to identify key characteristics of organisational problems, alongside features of PM methodologies and insights into their adoption and adaptation in relation to such characteristics. Secondly, I gain some understanding of current practice via a small scale practitioner survey ($n = 31$) followed by semi-structured interviews, with a focus on PM methodological practices in the presence of complexity and volatility.
I then combine the results from literature analysis and survey to propose a fine grain mapping between volatility and complexity problem dimensions and predictive and adaptive risk controls, as a first step towards the systematisation of hybrid combinations in projects. Simultaneously, I use a case study to interpret key PM concepts within the POE framework.

Finally, by drawing all my findings together, I propose a systematic approach to parametrise PM processes in the face of complexity and volatility with the objective to better mitigate the risks arising from them, which I test and validate in two case studies and a practitioner evaluation ($n = 7$).

1.3 Contribution to Knowledge and to Practice

This research contributes to knowledge through a novel application of an existing complex problem solving framework, POE, from the design and engineering domain to the project management discipline, together with the proposal and evaluation of a systematic approach to parametrise hybrid projects. It does so both by interpreting PM concepts within POE and by extending the framework to enable the characterisation and representation of project processes.

Besides this theoretical contribution, the research has a potential impact on practice by providing a systematic approach to help project managers calibrate their project methodologies and practices according to problem characteristics of complexity and volatility.

1.4 Thesis outline

The remainder of this thesis is structured as follows. Chapter 2 reviews current understanding of organisational problems, their characteristics and related risk together with an insight into complex PM and of acknowledged features of different PM methodologies, their current adoption in practice and the way in which they mitigate risk. In Chapter 3 I describe my research methodology. Chapter 4 describes to which extent POE concepts and constructs relate to PM and illustrates this relationship by means of a retrospective case study. Chapter 5 reports on findings from a practitioner survey, the objective of which was to understand which factors affect current choices of PM approaches made
by practitioners in organisations. To which extent problem characteristics can be used to help practitioners parametrise their PM processes is described in Chapter 6 and evaluated and discussed in Chapter 7. The thesis concludes with a discussion of the future work in Chapter 8.
Chapter 2

Literature review

In this dissertation, I explore the notion of PM as problem solving, with a focus on the extent to which the characteristics of organisational problems can inform choices of PM methodologies and effective ways to set up and manage projects.

Therefore, in this chapter, after introducing some basic PM definitions in Section 2.1, I look at characteristics of organisational problems in Section 2.2 focusing, in particular, on complexity and volatility, and the notion of project management as problem solving. In Section 2.3 I turn my attention to risk and risk management in projects, and the relation between risk and complexity and volatility. In Section 2.4 I outline standard measures of project success and discuss how different PM methodologies mitigate risk to increase the likelihood of success. Finally, in Section 2.5 I summarise the key findings from the literature, reflecting on how they inform the remainder of the dissertation.

2.1 Project Management basics

The Project Management Institute defines a project as “a temporary endeavor undertaken to create a unique product, service or result,” with project management “the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements” (Project Management Institute, 2013) within an idealised generic project life cycle, structured into four temporally contiguous phases (see Figure 2.1): starting the project, organising and preparing, carrying out project work, and closing the project. Each phase involves resource investment (dotted line) and is accompanied by specified deliverables. The expectation is that each project will exhibit such a life cycle, regardless of the specific PM process followed.
While PM processes can vary, the PMI still sets an expectation that any PM process should comprise the following five distinct process groups (sometime also called phases in the literature, which is a denomination that I avoid so that not to confuse them with the project life cycle phases): initiating, planning, executing, monitoring and controlling, and closing. The order in which process groups are executed will vary from project to project. PMI argues that, depending on the PM methodology applied, each life cycle phase may require the execution of each process group to some extent, perhaps more than once, so that, over time the emerging picture is similar to that in Figure 2.2, which gives an illustration of how the effort dedicated to each process groups may be distributed over either a phase or the whole project life cycle.

Specifically, with predictive methodologies (Project Management Institute, 2013), e.g., the Waterfall (Royce, 1970), what the project must deliver (its scope) and the time and cost required to deliver it are determined as early as practical in the project life cycle, so that the process groups are fully planned upfront and follow from one another in a linear manner. This means that there is a one-to-one mapping between process groups and life cycle phases.

Instead, in iterative and incremental methodologies (Larman and Basili, 2003), where
the scope is delivered in increments at each iteration, project groups may repeat within each phase. The same applies to *adaptive* methodologies, such as agile methodologies (Highsmith, 2009), which are also iterative and incremental, but are characterised by very rapid iterations, which are usually fixed in time and cost better to cope with change. Figure 2.3 gives an example of an agile project life cycle, where the process groups of planning and executing are repeated at each iteration.
2.2 Characteristics of organisational problems

In the early 70s, seminal work by Rittel and Webber (Rittel and Webber, 1973) in the context of social policy started to question the applicability of traditional problem solving and planning from the industrial age, focuses on notions of efficiency and optimisation, and rational, fully planned processes. They introduced the notion of **wicked problem** as one that cannot be easily framed, depends on differing stakeholder’ perspectives, defies any unique definition or single notion of solution, and whose requirements, constraints and resources to address it change over time, so that there are no definable “stopping rules.” Over the following decades, the concept became more and more influential in management science and beyond, applied in many domains whose problems exhibit such characteristics. Of particular relevance to this dissertation is the link with **design problems** (Conklin, 2006), which are seen as exhibiting many wicked characteristics, and often requiring the invention of novel, creative solutions. This view is in line with Problem Oriented Engineering (Hall, Rapanotti, and Jackson, 2008), the problem solving framework I will make use of in my research.

Many of the characteristics of wicked problems are recognisable in today’s organisational problems. As in wicked problems, “problem understanding and problem resolution are concomitant to each other” (Rittel and Webber, 1973), making it difficult to plan a project into fixed and well delimited phases. Some organisational problems are a symptom of other problems, which makes the problem solving even trickier. Moreover, the solution which is being implemented will have consequences on the organisation, which cannot be completely predicted beforehand. Likewise, there are no clear stopping rules: in the end, the judgement of the problem owner is the only valid criteria to declare an organisational problem as solved.

In this section I review literature which has dwelled on specific ‘wicked’ characteristics of organisational problems addressed by projects, specifically those of complexity and volatility.
2.2.1 Projects and complexity

Complexity has been explored extensively in the PM literature and a plethora of definitions exist. Few authors have attempted to synthesise some unified understanding. The comprehensive survey by Geraldi, Maylor, and Williams (2011), for instance, proposes five characterisations of complexity, as follows. The first, with roots in the work of Williams (1999) and Baccarini (1996), is \textit{structural} complexity, related to the existence of large number of distinct and interdependent elements. Next is \textit{uncertainty}, also inspired by Williams (1999), related to a number of factors, including risk, lack of information or knowledge, presence of ambiguity, lack of agreement, etc. Then come \textit{dynamics}, related to changes in goals, product specifications, management team or the environmental context, followed by \textit{pace}, related to urgency and time-criticality of goals. Finally \textit{socio-political} complexity relates to conflicting stakeholder’ interests and difficult personalities. It is worth noticing how uncertainly, dynamics and time-criticality are all considered dimensions of complexity, something I will challenge in this work. In the context of complex engineering projects, Bosch-Rekveldt et al. (2011) also considers \textit{environmental} complexity, in this case covering both geophysical elements, like weather conditions, market influences, like competition, and political influences.

According to Baccarini (1996), two common meanings of the term complexity are conflated in project complexity: structural complexity, mentioned above, as being related to many varied interrelated parts; and the characteristics of being “complicated, involved, intricate”. Indeed, Geraldi, Maylor, and Williams (2011)’s various characterisations relate to both. The distinction between complex and complicated is also made by other authors, for instance, Whitty and Maylor (2009), who take a complex system view of projects, so that a complex project is seen as one exhibiting emergent behaviour that cannot be inferred from its components, while a complicated project is one which is “intricate, involved, gled, and knotty.”

Structural complexity is by far the most common notion in the literature. Further qualifications follow two lines of thought: one related to the organisational structure and the social environment of a project, and the other to the technical complexity of the tasks to be performed in the project. Along these lines, Conklin (2006) differentiates between \textit{social complexity}, which relates to the number and diversity of stakeholders involved, and
technical complexity, based on the number of technologies involved and the number of possible interactions among them, although this notion also includes the rate of technical change. Similarly, Baccarini (1996) and Tiwana and Keil (2004) differentiate between organisational complexity rooted in the number of different organisational parts and their interdependence, and technological complexity, related to materials, production processes and technological knowledge required.

Ahern, Leavy, and Byrne (2014) focus on knowledge complexity in a wider sense, related to the fact that in complex projects not all that is relevant is completely known at the outset, as predictive PM methods would assume in their front-end project planning. Instead, they see complex project management as a form of organisational complex problem solving which continuously creates contextual emergent knowledge, which is distributed, untapped and even tacit. A similar perspective is expressed by Tiwana and Keil (2004) in the context of software projects, seen as a process of “embodying technical knowledge and knowledge of customer needs into a coherent [software] solution.”

Given the lack of a standard definition, from my analysis of the literature, I define complexity as related to the presence of many interconnected parts, which interact in complicated or unpredictable ways. This definition is closely aligned with structural complexity (Geraldi, Maylor, and Williams, 2011) in the literature. Moreover, I further qualify complexity along the dimensions of social, when related to people and their norms and cultural aspects, technical, when related to systems, structures and technologies, and knowledge, when related to what is known in form of distributed, tacit and non-codified knowledge. Table 2.1 indicates how my chosen definition relates to those I found in the literature.

2.2.2 Projects and volatility

In its common meaning, volatility relates to a propensity to change, often rapidly and unpredictably. As discussed in the previous section, notions of dynamics, time-criticality or pace of technological change are often conflated with complexity in the literature, while other authors (Sauer, Gemino, and Reich, 2007) have used the term volatility to indicate any change in a project, whether of governance, i.e., project manager or sponsor, or of target, i.e., schedule, budget or scope. I argue that conflating complexity and volatility is
Chapter 2. Literature review

12

Social

- (Conklin, 2006); socio-political (conflicting stakeholder interest and difficult personalities); uncertainty (lack of agreement) (Geraldi, Maylor, and Williams, 2011); environmental (political influences) (Bosch-Rekveldt et al., 2011); organisational (Baccarini, 1996; Tiwana and Keil, 2004)

Technical

- (Conklin, 2006); environmental (geophysical elements) (Bosch-Rekveldt et al., 2011); technological (materials and processes) (Baccarini, 1996; Tiwana and Keil, 2004)

Knowledge

- (Ahern, Leavy, and Byrne, 2014); knowledge of customer need (Tiwana and Keil, 2004); environmental (market influences) (Bosch-Rekveldt et al., 2011); technological (knowledge) (Baccarini, 1996; Tiwana and Keil, 2004)

Table 2.1: Complexity: coverage of the literature reviewed

problematic, as the risks arising from volatility are quite distinct from those arising from (structural) complexity: for instance, Gemino, Reich, and Sauer (2007) argue that risk related to complexity are potentially knowable at the start of a project, so that traditional risk management largely applies, while risks from volatility are by and large unknowable at the start and emerge during the project, requiring an approach more focused on uncertainty than traditional risk management (Ward and Chapman, 2003). I agree with this assessment, hence I take the view that volatility should be considered separately from complexity, and consider the above examples as manifestations of volatility. Note that in the software PM literature, volatility is often associated with requirements (Nurmuliani, Zowghi, and Powell, 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004), but this can be seen as an instance of Geraldi, Maylor, and Williams (2011)’s more general notion of dynamics.

Analogue to complexity, my literature analysis has highlighted the lack of a definitive notion of volatility. Therefore, in my work I define volatility as related to the likelihood of change, further qualified along the dimensions of social, technical and knowledge, as per complexity. Table 2.2 relates my definition to the literature.

2.2.3 Complexity and volatility factors

There is broad agreement in the literature that understanding complexity and volatility is important in PM (Baccarini, 1996; Remington, Zolin, and Turner, 2009), as they affect the way projects are planned, staffed and controlled, and can influence project success in
Social
volatility (target, governance) (Sauer, Gemino, and Reich, 2007); volatility (requirements) (Nurmuliani, Zowghi, and Powell, 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in management team or environmental context) (Geraldi, Maylor, and Williams, 2011)

Technical
technical (rate of technical change) (Conklin, 2006); volatility (target) (Sauer, Gemino, and Reich, 2007); volatility (requirements) (Nurmuliani, Zowghi, and Powell, 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in product specifications) (Geraldi, Maylor, and Williams, 2011)

Knowledge
volatility (requirements) (Nurmuliani, Zowghi, and Powell, 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in environmental context) (Geraldi, Maylor, and Williams, 2011)

<table>
<thead>
<tr>
<th>Social</th>
<th>Technical</th>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>volatility (target, governance) (Sauer, Gemino, and Reich, 2007); volatility (requirements) (Nurmuliani, Zowghi, and Powell, 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in management team or environmental context) (Geraldi, Maylor, and Williams, 2011)</td>
<td>technical (rate of technical change) (Conklin, 2006); volatility (target) (Sauer, Gemino, and Reich, 2007); volatility (requirements) (Nurmuliani, Zowghi, and Powell, 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in product specifications) (Geraldi, Maylor, and Williams, 2011)</td>
<td>volatility (requirements) (Nurmuliani, Zowghi, and Powell, 2004; Singh and Vyas, 2012; Tiwana and Keil, 2004); dynamics (change in environmental context) (Geraldi, Maylor, and Williams, 2011)</td>
</tr>
</tbody>
</table>

Table 2.2: Volatility: coverage of the literature reviewed

terms of scope delivery within time and budget (Baccarini, 1996). Hence, practitioners must be able to assess the level of complexity and volatility they are dealing with, to inform key stakeholder and take appropriate PM decisions (Remington, Zolin, and Turner, 2009). To this end, factors are considered which are sources of complexity or volatility in projects, alongside the metrics used to assess their severity or impact on project performance (Remington, Zolin, and Turner, 2009).

Few authors have proposed approaches to help practitioners make such an assessment early on in a project life cycle and in specific industries. For instance, Bosch-Rekveldt et al. (2011) propose a framework for project complexity in large engineering projects, which includes a wide range of factors for consideration, extracted from the literature and practitioners’ interviews, and classified under technical, organisational or environmental complexity. Similarly, Clarke and O’Connor (2012) propose a framework for software development projects, including technical and non-technical factors extracted from the literature. Still in the context of software development, Kalus and Kuhrmann (2013) go a step further by proposing both a comprehensive checklist covering elements of complexity from the literature, and matching them with suggested desirable software development practices, while Fitsilis (2009) proposes a framework for measuring software project complexity combining the the PMI’s Project Management Body of Knowledge with Geraldi and Adlbrecht (2007)’s typology of complexity: faith, as related to uncertainty, fact, as related to interdependent information and interaction in relation to the
interfaces between systems (Fitsilis, 2009). Further examples of industry specific measurements can be found in Lu et al. (2015), which introduces a model developed from the Shanghai World Expo construction project to measure project complexity in large-scale projects from task and organisation perspective, and in He et al. (2015), which deals with complexity of mega construction projects in China.

In my work, I am not industry specific, therefore I will consider factors from the literature which are general enough to be relevant across a wide range of projects. I have summarised them in Table 2.3, with reference to my definitions of complexity and volatility and their dimensions. I have also coded them for ease of reference throughout the dissertation, as I will return to them in later chapters.

The first entries in Table 2.3 are related to the structural definition of complexity. Baccarini (1996) and Williams (1999), for instance, identify the dimensions of organisational and technological and the characteristics of differentiation and interdependence as sources of complexity (Fitsilis, 2009). These dimensions are reflected in the factors: large numbers of stakeholder or organisational units involved (NUMSOC), diversity of stakeholder (DIVSOC) and large number of technologies or interfaces involved (NUMTEC), which can be categorised as, respectively, social (NUMSOC and DIVSOC) and technical complexity (NUMTEC).

Uncertainty of goals, unclear meanings or stakeholder’ hidden agendas (UNCERGOAL) are acknowledged as the manifestation of the inability of the stakeholder to interact due to social complexity (Saynisch, 2010; Williams, 1999). Similarly, complicated communication due to organisational or technical characteristics (COMPLCOMM), is identified by Lu et al. (2015) as a manifestation of either social or technical complexity.

Other authors such as Ahern, Leavy, and Byrne (2014) concentrate on knowledge and identify the lack of pre-given knowledge at project start (KNOWLEGEST), as a source of complexity. A similar approach is followed by Geraldi and Adlbrecht (2007), who mention the subjective concept of faith as an indication of the uncertainty which decreases as the project progress.

Changing organisations (CHANGESOC), technologies (CHANGETEC) or context (CHANGEENV) are mentioned by several authors as source of volatility (Whitty and Maylor, 2009; Conklin, 2006; He et al., 2015; Lu et al., 2015), while others explicitly add
### Table 2.3: Factors related to complexity and volatility

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Factor</th>
<th>Code</th>
<th>Mentioned by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Complexity</td>
<td>Large number of stakeholder or organisational units involved</td>
<td>NUMSOC</td>
<td>(Baccarini, Salm, and Love, 2004), (Williams, 1999), (Conklin, 2006), (Girmscheid and Brockmann, 2008)</td>
</tr>
<tr>
<td></td>
<td>Diversity of stakeholder</td>
<td>DIVSOC</td>
<td>(Girmscheid and Brockmann, 2008), (Conklin, 2006)</td>
</tr>
<tr>
<td>Technical Complexity</td>
<td>Large number of technologies or interfaces involved</td>
<td>NUMTEC</td>
<td>(Baccarini, Salm, and Love, 2004), (Williams, 1999), (Conklin, 2006), (Girmscheid and Brockmann, 2008)</td>
</tr>
<tr>
<td>Knowledge Complexity</td>
<td>Lack of pre-given knowledge at project start</td>
<td>KNOWLEGEST</td>
<td>(Ahern, Leavy, and Byrne, 2014)</td>
</tr>
<tr>
<td>Social &amp; Technical</td>
<td>Complicated communication due to organisational or technical characteristics</td>
<td>COMPLCOMM</td>
<td>(Lu et al., 2015)</td>
</tr>
<tr>
<td>Complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social &amp; Knowledge</td>
<td>Uncertainty of goals, unclear meanings or stakeholder’ hidden agenda</td>
<td>UNCEGOAL</td>
<td>(Saynisch, 2010), (Williams, 1999)</td>
</tr>
<tr>
<td>Complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Volatility</td>
<td>Rate of change in the organisation</td>
<td>CHANGESOC</td>
<td>(Whitty and Maylor, 2009)</td>
</tr>
<tr>
<td>Technical Volatility</td>
<td>Rate of change in the technical solution</td>
<td>CHANGETEC</td>
<td>(Conklin, 2006), (Whitty and Maylor, 2009)</td>
</tr>
<tr>
<td></td>
<td>Novelty or uniqueness of the technical solution</td>
<td>NOVELTEC</td>
<td>(Geraldi and Adlbrecht, 2007)</td>
</tr>
<tr>
<td>Knowledge Volatility</td>
<td>Rate of change in the external environment, such as legal regulations</td>
<td>CHANGENV</td>
<td>(He et al., 2015), (Lu et al., 2015)</td>
</tr>
<tr>
<td>Social, Technical &amp;</td>
<td>Urgency or criticality of time goals</td>
<td>URGENCY</td>
<td>(Geraldi, Maylor, and Williams, 2011)</td>
</tr>
<tr>
<td>Knowledge volatility</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
uniqueness or novelty of the task or technology (NOVELTEC) as additional sources of volatility (Geraldi and Adlbrecht, 2007).

Urgency (URGENCY) or criticality of time goals is mentioned in the literature in relation to any type of volatility (Geraldi, Maylor, and Williams, 2011) as a response to changing organisation, technology or context. Changing technology, for instance, can make an implementation obsolete, and thus require that the implementation finishes urgently before the change happens. Similar examples apply to changing organisations or changing environments.

From my description above, I can observe that not only URGENCY can be linked to more than one category. COMPLCOMM, as well, can be related to Social and Technical complexity and UNCERGOAL to Social and Knowledge complexity. I need to highlight that, although the categorisation of complexity and volatility into social, technical and knowledge is rooted in the literature, a strict separation does not always apply. This can be explained by the fact that organisational problems deal mostly with socio-technical systems. In such problems, where technology and people interact (Hall and Rapanotti, 2009), the separation into the dimensions of social and technical is unclear. A similar reasoning applies to knowledge complexity, where the amount to be known is often a reflection of the presence of technical and/or social complexity.

The factors considered in Table 2.3 will be introduced again in this chapter in relation to risk and risk mitigation, and in Chapter 5 as prompts in the survey set up to investigate which factors affect current choices of PM approaches made by practitioners in organisations. Furthermore, they will be used again in Chapter 4 as part of my complexity and volatility framework.

### 2.2.4 Complex project management as complex problem solving

In the context of complex projects, Ahern, Leavy, and Byrne (2014) criticise predictive PM methodologies as focusing on planning and control by assuming full pre-given knowledge, so that projects can be completely specified in advance — a characteristic of complicated rather than complex projects. Instead, they argue, managing complex projects is a form of complex problem solving, requiring careful knowledge management: project execution is then a learning process characterised by the creation of emergent knowledge
and its coordination through “a common will of mutual interest” among stakeholder –
a process of self-organisation, rather than of detailed planning, around mutually agreed
project goals. The knowledge gaps at the start of a complex project stem both from un-
tapped tacit knowledge within an organisation and from other unknowns (Cleden, 2017)
which may only emerge over time, something which is particularly challenging for pre-
dictive project risk management (more about this in Section 2.3.1), as the assumption that
all risks can be estimated up-front does not hold (Pritchard, 2014).

Note that Ahern, Leavy, and Byrne (2014)’s view emphasises the contextual speci-
ficity of complex projects (Engwall, 2003), as operating on the contextual knowledge of
the project team as a community of learners delivering the project. This view of a complex
project encompasses both notions of complexity and volatility I have discussed above.

It is important to stress that Ahern, Leavy, and Byrne (2014)’s critique does not mean
that all formal PM practices should be abandoned, but only that planning is necessar-
illy bounded in that it involves “continuously creating the contextual knowledge that is
unspecifiable at the outset [...] and coordinating this emergent knowledge through the
agency of a common will of mutual interest.” This is echoed by Tiwana and Keil (2004),
whose study found that the adoption of formal PM practices, such as formal plans,
schedules, budgets, and milestones, is an important contributor to project success: akin
to Ahern, Leavy, and Byrne (2014)’s bounded planning, such practices are meant as
well-defined patterns and directives for “coordinating interactions and integrating in-
puts from various project constituent.”

Ahern, Leavy, and Byrne (2014)’s view of managing complex projects as a form of
complex problem solving is core to this dissertation, and will be explored in detail from
Chapter 4 onwards.
2.3 Project risk

![The Iron triangle](image)

Cost, time and quality (The Iron Triangle, Figure 2.4) have been the most commonly applied criteria to measure project success for decades (Atkinson, 1999), further qualified into process and product performance (Barki, Rivard, and Talbot, 2001; Nidumolu, 1996; Ropponen and Lyytinen, 2000; Faraj and Sproull, 2000): process performance relates to project efficiency and is measured by adherence to cost and time estimates (Nidumolu, 1996; Wallace and Keil, 2004); product performance relates to the outcome of the project (its scope) in terms of product quality and realised benefits (Barki, Rivard, and Talbot, 2001; Nidumolu, 1996). Therefore, overall project performance is measured in terms of budget and schedule (process performance) and of scope (product performance). Indeed, within a project these elements may compensate for each other: a delay in schedule, for instance, can be compensated with more budget, or the scope can be reduced in order to achieve the target budget and schedule.

Project success is threatened by project risk. In general terms, risk can be defined as “the likelihood that a hazard will result in harm” (Fafinski, 2008) or, more simply, the possibility of something bad happening.

The assessment of risk has evolved with time. In the middle ages, risk was related to the possibility of an objective danger or Act of God that could not be imputed to wrongful
conduct. It was characterised by a lack of human control and hence blame could not be attributed (Fafinski, 2008).

With time, there was a trend to include human responsibility and blame attribution. Unanticipated outcomes could be the consequence of careless human behaviour rather than fate. Risk started to be assessed in terms of the scale of its consequences and the likelihood that it will occur, hence was defined as the product of the probability and consequences (magnitude and severity) of an adverse event (that is, a hazard) (Bradbury, 1989). This type of approach is called the realistic perspective and is used by several disciplines to quantify risk (Fafinski, 2008). Project Management is one of them, as I consider next.

2.3.1 Risk classification and risk management strategies

The PMI defines risk as “an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more projects objectives” (Project Management Institute, 2013). Project risk has its origins in the uncertainty present in all projects and risk management is part of the project management standards: its objective is to decrease the likelihood of negative events in a project (Project Management Institute, 2013). Risk in projects is typically evaluated in terms of the monetary effect derived from its occurrence and likelihood.

There are many ways of classifying risk in projects. The PMI classifies risk according to several criteria, such as its causes, project objectives or project phases, organised according to the structure reproduced in Figure 2.5: this provides a hierarchical representation of risk factors, categorised as technical, external, organisational and of project management.

Project risk management is an important PM topic, not only for practitioners but for scholars as well (Zhang and Fan, 2014). It includes three processes: risk identification, which consists of recognising and documenting the associated risk, risk analysis, which exams each risk issue in order to assess the associated impact and risk treatment or risk control, which deals with the implementation of strategies, in order to either reduce the likelihood of occurrence or lower the negative impact (Fan, Lin, and Sheu, 2008).
According to Standardization (2009) “a control is a measure used to modify risk” and it includes any process, policy, device or other actions which have the object to modify risk, either by reducing the possibility of occurrence or the impact (Aven, 2011). Risk treatment is, accordingly, the process by which either “existing controls are improved or new controls are developed and implemented” (Purdy, 2010).

When applied to project management, risk control plays an important role in mitigating the negative impact of project risks (Miller and Lessard, 2001). Project Management Institute (2017a), for instance, recommends to use expert judgement and interpersonal team skills as the tools to plan and implement risk-control strategies, mostly based on the experience or preference toward risk of the project managers. However, it is widely accepted that project characteristics are critical to the success of the chosen risk response (Fan, Lin, and Sheu, 2008).

Project Management Institute (2013) classifies different risk controls into four types of strategy to respond to risk in a project:

![Figure 2.5: Extract from Sample Risk Breakdown Structure (RBS) from Project Management Institute (2017a)](image-url)
• **risk avoidance**, where the project team acts to avoid the risk and eliminate the threat or protect the project from its impact, for instance applying the *risk control* of reducing scope in case of possible unavailability of resources;

• **risk transfer**, where the project team transfers the risk, for instance by applying the *risk control* to transfer liabilities to third parties;

• **risk mitigation**, where the project team acts to reduce the probability of occurrence or impact of a risk, for instance applying the *risk control* of setting up a prototype before starting with the development of the final product;

• **risk acceptance**, where the project team accepts the risk, for instance when acknowledging the risk and establishing a contingency reserve to handle it. (Note that this risk management strategy implies not attempting to modify the risk by means of a *risk control* but to prepare a reaction to its occurrence)

These risk strategies are based on the assumption that all risks can be estimated up-front in terms of their likelihood and impact (Pritchard, 2014; Project Management Institute, 2013), something which is brought into question in complex projects, where both risk and related relevant knowledge may only emerge over time (Ahern, Leavy, and Byrne, 2014; Cleden, 2017). Acknowledging this issue, some authors have attempted different risk classifications.

For instance, Gemino, Reich, and Sauer (2007) re-classify risk factors depending on whether they can be identified before or after project start, as shown in Figure 2.6. Following this temporal view, project risk tends to decrease as the project goes on as uncertainty diminishes and the actual performance becomes more evident. It is interesting to note that, according to this classification, structural elements, which are mostly related to complexity, are considered knowable at project start, and thus can be mitigated using predictive PM methodologies, while volatile elements, which are associated with project variances (Sauer, Gemino, and Reich, 2007), are by and large unknowable at the start and emerge during the project, requiring an adaptive approach more focused on uncertainty than traditional risk management (Gemino, Reich, and Sauer, 2007; Ward and Chapman, 2003).
This view is consistent with the concept of controllability, which is given by the degree in which the project team can have an influence on the risk. Technical, scheduling or budget issues, for instance, are typical examples of high degree of controllability, in contrast to unexpected events, which are difficult to control (Fan, Lin, and Sheu, 2008). Based on the degree of controllability of the risk, risk treatment has been classified in two categories: risk prevention, when it refers to the actions taken in the planning stage to reduce probability of occurrence and risk adaptation when refers to the actions taken to mitigate the risks, when the probability of occurrence cannot be controlled (Royer, 2000; Miller and Lessard, 2001).

<table>
<thead>
<tr>
<th>Proposed risk factor categories</th>
<th>A priori risks</th>
<th>Emergent risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Structure</td>
<td>Organizational support</td>
</tr>
<tr>
<td>Degree of novelty</td>
<td>Technological complexity, project size</td>
<td>User involvement</td>
</tr>
<tr>
<td>Experience with the technology</td>
<td>Project size</td>
<td></td>
</tr>
<tr>
<td>Expertise (lack of knowledge), technological newness (need for new software and hardware)</td>
<td>Application size, technical complexity</td>
<td>Organizational environment, expertise (user support)</td>
</tr>
<tr>
<td>Misunderstanding requirements, managing user expectations, lack of knowledge, changing requirements</td>
<td>Top management support, user commitment, lack of user involvement, inappropriate staffing</td>
<td></td>
</tr>
<tr>
<td>Requirement management risks</td>
<td>System functionality risks</td>
<td>Resource usage and performance risks, personnel management risks</td>
</tr>
<tr>
<td>Team risk, requirements risk</td>
<td>Complexity risks, planning and control risks</td>
<td>Organizational environment risk (organizational support), user risks</td>
</tr>
<tr>
<td>Experienced project manager, standard software infrastructure, firm requirements</td>
<td>Minimize scope, reliable estimates</td>
<td>Top management support, user involvement</td>
</tr>
</tbody>
</table>

**Figure 2.6:** Risks factors and categories (Gemino, Reich, and Sauer, 2007)
2.3.2 Risk vs uncertainty

While uncertainty is often equated to risk, there are important differences. From a PM perspective, risks must be identifiable via the threats they embody, and quantified in terms of the likelihood and severity of their consequences (Cleden, 2017). This is not always possible with uncertainty. More precisely, and by taking a knowledge-centric view, Cleden (2017) observes that all projects start with inherent uncertainty and an important part of PM and its risk analysis is to transform such uncertainty by separating risk (‘known unknowns’) from knowledge (‘known knowns’) and untapped knowledge (‘unknown knowns’), until what is left are the unpredictable events and knowledge gaps I may not be aware of (‘unknown unknowns’). This latent uncertainty is ‘unfathomable’, either because I do not know it exists or because I have no way to assess or understand it. Dealing with latent uncertainty requires different strategies beyond traditional risk management, such as experimentation and the continuous generation of knowledge though the complete project life cycle (Ahern, Leavy, and Byrne, 2014): in particular, fast iterations of learning (learning loops) may reduce areas of uncertainty and allow the project to react quickly to emerging problems, assuming the project is sufficiently adaptive (Cleden, 2017).

Both complexity and volatility are acknowledged sources of uncertainty (Gemino, Reich, and Sauer, 2007; Sauer, Gemino, and Reich, 2007; Vidal and Marle, 2008; Cleden, 2017): assessing them is then a way to gain some indication of the level of latent uncertainty in a project, hence which PM methodologies and practices are more likely to lead to project success.

Predictive PM methodologies, like the classic Waterfall (Royce, 1970), strive to follow an orderly and linear process, which Conklin (2006) describes as “a picture of already knowing.” Instead, as previously observed, today’s organisational problems have a large knowledge component, so that problem solving is more like “a picture of learning”: the more novel the problem or its solution, the more the problem solving process involves learning about problem and solution domains.

Aligned to this, is the work of Ahern, Leavy, and Byrne (2014), which identifies different modes of problem solving based on level and pace of knowledge change (see Figure 2.7), as well as the type of risk or uncertainty involved. According to them, complex
problem solving is one characterised by high levels of knowledge change at a pace that can be very high, and with uncertainty that can only be estimated. It is worth noticing that that work makes a distinction between complex and wicked problems, the latter characterised by uncertainty as unfathomables (unknown unknowns).

![Diagram of modes of problem solving]

**Figure 2.7:** Modes of problem solving - knowledge change & pace of knowledge change. (Ahern, Leavy, and Byrne, 2014)

### 2.3.3 Risk from complexity and volatility

Earlier in this chapter, in Section 2.2.3, I identified and classified factors which are sources of complexity and volatility. In this section, I return to them to increase my understanding of their related risk. The outcome of my analysis is recorded in Table 2.4.

As already discussed, complexity is a widely acknowledged critical dimension for PM and the trigger of managerial actions required to ensure successful project completion (Baccarini, 1996; Bennett, 1991). The existence of many interconnected parts interacting in complicated or unpredictable ways are a source of risk throughout the project life cycle.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Factor</th>
<th>Manifests</th>
<th>Effects</th>
<th>Impact on project success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Complexity</td>
<td>NUMSOC</td>
<td>Increase of interactions and complicated communication (Lu et al., 2015)</td>
<td>Increase of coordination effort (Lu et al., 2015)</td>
<td>Overrun of time and budget</td>
</tr>
<tr>
<td></td>
<td>DIVSOC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Complexity</td>
<td>NUMTEC</td>
<td>Affect ability to predict behaviour (Whitty and Maylor, 2009)</td>
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</tr>
<tr>
<td>Knowledge Complexity</td>
<td>KNOWLEDGEST</td>
<td>Information fragmentation (Conklin, 2006)</td>
<td>Stakeholders attempt to sabotage project (Conklin, 2006)</td>
<td>Complete project failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stakeholder holding different understanding of the problem (Conklin, 2006)</td>
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<tr>
<td></td>
<td></td>
<td>Multiple objectives (He et al., 2015)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unclear goals and objectives (UNCERGOAL) (Conklin, 2006)</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Social &amp; Technical Complexity</td>
<td>COMPLCOMM</td>
<td>Increase of interactions and complicated communication (Lu et al., 2015)</td>
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<td>Overrun of time and budget</td>
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<td>Shifting requirements (Tiwana and Keil, 2004)</td>
<td>Additional effort and expensive reworking due to continuous changes (Tiwana and Keil, 2004)</td>
<td>Overrun of time and budget</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-aligned goals with key stakeholder (Geraldi, Maylor, and Williams, 2011)</td>
<td>Complete project failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Complete project failure</td>
</tr>
<tr>
<td>Technical Volatility</td>
<td>CHANGETEC</td>
<td>Produces new technical solutions and drop others into oblivion (Conklin, 2006)</td>
<td>Developing obsolete solution (Conklin, 2006)</td>
<td>Solution goes to waste</td>
</tr>
<tr>
<td>Knowledge Volatility</td>
<td>CHANGEENV</td>
<td>Elements of the project are difficult to control (Lu et al., 2015)</td>
<td>High level of disorder, rework or inefficiency (Lu et al., 2015)</td>
<td>Overrun of time and budget</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-aligned goals with the environment(Geraldi, Maylor, and Williams, 2011)</td>
<td>Complete project failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Crane project failure (Geraldi, Maylor, and Williams, 2011)</td>
<td>Complete project failure</td>
</tr>
<tr>
<td>Social, Technical &amp; Knowledge</td>
<td>URGENCY</td>
<td>Increases the need of coordination and the interdependence between the project components (Williams, 1999)</td>
<td>Small problems or uncertainties cause unexpectedly large effects that may lead to greater overspend (Williams, 2005)</td>
<td>Overrun of time and budget</td>
</tr>
</tbody>
</table>

**Table 2.4:** Manifestation of complexity & volatility, effects and impact on project success
Chapter 2. Literature review

Complexity can make coordination so challenging that it may lead the development of the solution to fail (Tiwana and Keil, 2004), thus affecting the project success objectives of time, cost and quality (Baccarini, 1996).

Social complexity, in the form of interdependence among a large number, or diverse project stakeholders (NUMSOC, DIVSOC), will increase the number of interactions and, accordingly, complicate the communication (COMPLCOMM). In consequence, there will be a higher need of coordination which will require time and effort and may result either in project delays or in budget increase to compensate.

Social complexity, due to the number and diversity of stakeholder (NUMSOC, DIVSOC), together with knowledge complexity, in terms of what is not known at the start of the project (KNOWLEDGEST), may lead to information fragmentation, with stakeholders holding different understanding of the problem (Conklin, 2006), hence having multiple, possibly conflicting, objectives (He et al., 2015) and hindering the clear identification of project goals (Conklin, 2006) (UNCERGOALS). The failure to identify which stakeholders are affected by the project generates the risk that those stakeholder may attempt to stop, undermine or even sabotage it (Conklin, 2006).

Technical complexity, driven by the number and nature of the technical components and interactions (NUMTEC), will increase the difficulty to understand and to predict long-term or emergent behaviour of the technical components (Whitty and Maylor, 2009), thus affecting the quality of the project plan. A bad project plan will expose the project to feasibility, budget, and scheduling risks (Tiwana and Keil, 2004) and more specifically to scope creep, because of not understanding the effort properly (Schmidt, Lyytinen, and Mark Keil, 2001), with the consequence of time and budget overruns.

Social volatility (CHANGESOC), manifested in shifting requirements, will require additional effort and expensive reworking in order to adapt the solution in progress to the continuous changes (Tiwana and Keil, 2004).

Technical volatility, in the form of quickly evolving technical environments (CHANGETEC, NOVELTEC), will produce new technical solutions and drop others into oblivion, increasing the risk of developing an obsolete solution (Conklin, 2006). When applied to software projects, this risk is called developmental risk, as the solution developed under such conditions, might go completely to waste.
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Knowledge complexity, manifested in changes in the external environment (CHANGEENV), may well affect the elements of the project, which, due to the adaptations required to adapt to the changes in the environment, will become difficult to control (Lu et al., 2015). Changes may lead to high level of disorder, rework or inefficiency, if not well communicated or managed.

In the case of changing organisations (CHANGESOC) and/or context (CHANGEENV), project goals may no longer be aligned with the key stakeholder or with the environment (Geraldi and Adlbrecht, 2007). This may lead to complete project failure, either because the key stakeholders do not need the deliverables anymore or, because changes in market or in regulations, make the project scope obsolete or impossible.

Criticality of time goals (URGENCY) increases the need of coordination to meet tighter project timeframes and the interdependence between the project components (Williams, 1999). As a result of this interdependence, small problems or uncertainties cause unexpectedly large effects that may lead to greater overspending (Williams, 2005).

The way in which PM methodologies address the risk related to complexity and volatility is addressed in the next section.

2.4 Project management methodologies

The correlation between project success and choice of methodology has been evidenced in the literature. For instance, based on a large-scale survey, Joslin and Müller (2015) estimated that the application of a PM methodology accounts for 22.3% of the variation in project success, when measured against the overall project objectives, while a study reported in Tiwana and Keil (2004) indicated that the choice of methodology was the most critical risk factor in software projects.

In this section I discuss existing PM methodologies, the type of projects they are traditionally applied to, and the way they handle project risk.
2.4.1 From predictive to adaptive methodologies

A project management methodology is defined by the PMI as a set of methods, techniques, procedures, rules, templates, and best practices used on a project (Project Management Institute, 2013).

Since the 50s, project management principles, methods and procedures have been established to ensure robustness and applicability to a wide range of projects. At the beginning, approaches were both rational and normative, aimed at making it easy to plan a project and to follow the plan without deviations (Špundak, 2014). In the 70s, however, particularly in the context of software development, PM approaches started to evolve, leading to new iterative and incremental development methodologies (Larman and Basili, 2003) whose basic idea is that a software product is developed iteratively in subsequent increments, allowing the developer to learn from previous iterations (Basil and Turner, 1975). A notable example is Boehm’s spiral model, where at each iteration in the spiral, risk is identified and resolved. This risk-driven approach focuses on developing specifications appropriate to the stage of the design, prototyping as a risk-reduction option and accommodating reworks as new risks or opportunities arise (Boehm, 1988).

In the 90s, still mainly in the context of software development, several new approaches started to appear under several names, such as ‘agile’, ‘lean’ or ‘adaptive’, as a reaction to what were considered heavy-weight plan-driven predictive PM approaches. At their core was a desire to embrace rather than control change: they all share adaptability to change during the project life cycle as a key characteristic (Špundak, 2014). Adaptive PM methodologies have now become popular beyond software development (Highsmith, 2009; Cobb, 2011) and are widely applied alongside, and often combined with, predictive ones.

Boehm and Turner (2004) summarises key features of predictive vs. adaptive methodologies with reference to software projects, although their summary has more general validity. In their view, predictive PM is characterised by up-front planning, tightly controlled processes and activities and explicit documentation. It emphasises process predictability, maturity and repeatability, so that solutions can be delivered in compliance with external quality standards. Instead, adaptive PM emphasises emergent knowledge (Bider, 2014) and continuous adaptation to change via lightweight processes made of fast
and frequent iterations, with high reliance on tacit knowledge, high performing project teams and verbal communication. Solution quality is equated to the value delivered to the customer, who has a close relationship with the team throughout the project.

Predictive methodologies favour sequential delivery, with related tasked grouped together in stages according to a logical sequence of work, while agile methodologies adopt incremental delivery, with outputs iteratively refined in successive cycles, where mini versions of those logical work sequences are repeated. The delivery model impacts how risk and uncertainty are handled (Cleden, 2017): in sequential delivery, gateways between stages prevent spillovers from one stage to the next, while in incremental delivery, retrospective reviews are used to learn lessons from one release cycle to the next. Sequential delivery assumes stability and predictability from the start, while incremental delivery assumes a dynamic environment where many factors may change. Organisational culture is also an issue, as being adaptive requires relinquishing central control in favour of power distribution and team self-organisation, something not required by predictive methodologies.

As a consequence, the two methodologies are often seen as antithetic, each with its own home ground (Boehm and Turner, 2004): large, structurally complex systems and project teams in highly regulated industries with fairly stable requirements, for predictive PM; small systems and teams, in volatile environments and with readily available users and customers, for adaptive PM.

2.4.2 The rise of hybrid PM methodologies

There is an increasing recognition of the benefits of combining the discipline of predictive methodologies with the flexibility of adaptive ones (Boehm and Turner, 2004; Kuusinen et al., 2016). While trends of hybrid integration have been identified, evidence is still sparse, and it is mainly confined to the domain of software development projects. In particular, there are gaps in my understanding of how to perform such an integration effectively, which specific patterns to apply, and what the rationale behind specific combinations might be (Theocharis et al., 2015). Addressing such a gap is the overarching aim of my research.
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Since the introduction of agile methodologies in software development, some research has been conducted to investigate which such methods are in use by software developers (e.g., Vijayasarathy and Butler (2016) and Kuhrmann et al. (2018)), although the process by which practitioners choose and adapt methodologies is not addressed. Tripp and Armstrong (2014) concentrates on drivers for adopting agile methods, identifying as key reasons “a desire for increased software quality, increased efficiency, or increased effectiveness.” However, the work also admits that there are complex relations between motives and practices yet to be discovered. Other authors, such as West et al. (2011), have focused on the reasons why agile methods are not used in their pure form. Their findings indicate that organisations’ adoption is constrained by culture and the fact that organisations “have built up decades of traditional management tools, budgets, plans, architecture road maps, and requirements specifications,” which makes it challenging to adopt agility beyond small experiments used to address easily described problems, rather than situations with many unknowns and where requirements are not easily defined upfront (West et al., 2011). Similarly, Theocharis et al. (2015) postulates that the use of hybrid methods is due to the reluctance of management to embrace agile methods.

Boehm and Turner (2003) examines the aspects of agile and plan-driven methods and provides an approach to balance the application of PM methodologies based on risk. An overall risk strategy is established by integrating individual risk mitigation plans which are monitored and readjusted during the development of the project. In this approach, environmental risks are classified into agile and plan driven while the type of project methodology follows the type of risk. In case that both types of risk are present, the application should be architected so that to encapsulate the agile parts of the project and apply a plan driven strategy to the rest (Boehm and Turner, 2003).

A specific hybrid method proposed fairly recently, is the so-called ‘Water-Scrum-Fall’ (West et al., 2011; Theocharis et al., 2015), where the Waterfall (Royce, 1970) is a very well known predictive PM methodology and Scrum (Schwaber, 1997), an equally well known agile one. This hybrid method attempts to balance the ideas behind agility against the realities of organisational cultures more inclined towards traditional planning, budgeting, governance and control (West et al., 2011).
In ‘Water-Scrum-Fall’ requirements analysis and planning (the ‘Water’) are done before a Scrum team is put together to develop the software. However, while the Scrum team delivers software frequently, as the method dictates, the actual product release process (the ‘Fall’) delivers software to customers at intervals dictated by a separate release plan, so that development and release follow different tempi. While this is a specific hybrid combination, (West et al., 2011) predicts that in future PM processes will become less about a particular method and more about “applying the right mix of practices and techniques to the situation and problem.” Understanding what the right mix might be on a project basis is one of the objectives of my work.

Along these lines, Adelakun et al., 2017 investigated practices within the IBM Centre of Excellence in Chicago, US, observing emerging PM hybrids characterised by loose planning, but extensive coordination with PM serving as gatekeeper, and, in terms of scope management, loosely defined constraints at project start, but continuous monitoring and some adaptation throughout the process to avoid customer dissatisfaction or contract violation. In those projects, they observed that documentation remained an integral part, but its formality or frequency was project dependent. Also, while continuous feedback was regularly elicited from the customer, it fell short of direct involvement, with project teams not fully self-organised and managed, but empowered within a hierarchical organisational structure.

Also in the area of IT solution delivery, a learning-oriented hybrid agile approach, the Disciplined Agile Delivery (DAD) builds upon the foundation of several agile methods and software process frameworks, while introducing predictive elements to support a full delivery life cycle and enable tactical scaling (Ambler and Lines, 2012). Scaling refers not only using agile methods to deal with large teams that may be geographically distributed but also applying agile to a range of problem and solution complexities, multiple organisations or compliance topics (Ambler and Lines, 2016).

Still in the domain of software development projects, Vijayasarathy and Butler (2016) attempts to explain the selection of software development approaches (i.e., Agile, Predictive, Iterative and Hybrid) based three main factors: organisation size, criticality and size of project, and size and number of teams involved. A summary of their findings is given in Table 2.5.
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<table>
<thead>
<tr>
<th>Approach</th>
<th>Organisational</th>
<th>Project</th>
<th>Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agile</td>
<td>Moderate revenue, a small number of employees</td>
<td>Low budget, medium to high criticality</td>
<td>One, small team</td>
</tr>
<tr>
<td>Predictive</td>
<td>High revenue, a large number of employees</td>
<td>High budget and criticality</td>
<td>Multiple, medium teams</td>
</tr>
<tr>
<td>Iterative</td>
<td>A small number of employees</td>
<td>Medium budget and medium to high criticality</td>
<td>One, small team</td>
</tr>
<tr>
<td>Hybrid</td>
<td>Organization size is unimportant</td>
<td>Medium budget and high criticality</td>
<td>Small team</td>
</tr>
</tbody>
</table>

Table 2.5: Characteristics of the projects following the four software development approaches (Vijayasarathy and Butler, 2016)

In conclusion, there is little evidence of research on how practitioners choose and adapt project methodologies for use in their organisations, and the evidence which exists is mainly limited to software development projects, where the main focus is the adoption of agile methodologies. Instead, in my work I aim to address how to perform such an integration effectively and in general case, with reference to specific complexity and volatility problem characteristics.

2.4.3 PM methodologies and risk management strategies

As previously explained, project risk has an impact on project success so that an important aspect of PM is to deal with risk affecting product and process performance.

The risks arising from the different types of complexity and volatility require different risk control strategies. Section 2.3.1 discussed how risk management is part of PM standards: its objective is to decrease the likelihood of negative events in a project (Project Management Institute, 2013). Moreover, I discussed the classification of risk treatment into: risk prevention, when it refers to the actions taken in the planning stage to reduce probability of occurrence and risk adaptation when it refers to the actions taken to mitigate the risks, when the probability of occurrence cannot be controlled (Royer, 2000; Miller and Lessard, 2001) based on the controllability of the risk.

I can observe that, on a high level, risk prevention can be related to predictive PM methodologies, with focus on planning and control, while, risk adaptation can be related
to adaptive PM methodologies, where short iterations are used to minimise the impact of change.

On a more detailed level, it is possible to interpret how predictive and adaptive PM methodologies apply different risk controls using the traditional classification of risk management strategies proposed by the Project Management Institute (2013), which include risk avoidance, transfer, mitigation and acceptance.

In order to avoid risks, predictive methodologies apply tightly controlled processes and activities, and explicit documentation by means of strict control of changes and explicit requirements definition. Instead, adaptive methodologies resort to lightweight processes made of fast and frequent iterations leading to small product releases, each comprising “the maximum amount of validated learning about customers with the least effort” (Ries, 2011).

In order to transfer risks, predictive methodologies use formal quality gates in which the relevant stakeholder are requested to validate formally the results of each problem phase so that to ensure that risk is not carried from one project phase to the next. Adaptive methodologies, on the other hand, turn to close (verbal) communication with the relevant stakeholder, particular problem owners, to ensure that their requirements are understood and implemented.

Predictive methodologies mitigate the probability of incurring into risks by enforcing tightly controlled processes and avoiding changes. Adaptive methodologies, instead, resort to short iterations to minimise the impact of change, and to retrospectives to learn lessons from previous iterations and, in this way, reduce the possibility of risk occurrence.

Predictive methodologies use contingency plans for risks which have been accepted, while adaptive methodologies, once again, turn to short iterations and retrospectives for the same purpose.

A summary of the risk controls applied by predictive and adaptive methodologies is given in Table 2.6.

### 2.4.4 How PM methodologies manage risk from complexity and volatility

In Section 2.3.3, I discussed risk derived from complexity and volatility. In this section, I look at the different risk controls that PM methodologies apply in order to mitigate them.
As already mentioned in Section 2.3.1, risk treatment can be classified into risk prevention and risk adaptation. This classification is based on the degree of controllability of the risk, which is given by the degree in which the project team can have an influence on the risk. The concept of controllability can be related to complexity and volatility. Risk arising from complexity is mostly known at the start and its treatment can be planned; on the other hand, risk arising from volatility unfolds during the project life cycle and is based on the probability of change, which is external to the project. Therefore, the control of risk arising from complexity will be based on reducing the probability of the risk, while the one rising from volatility, on reducing the effects of the change. This is also consistent with my previous observation that, at a high level, risk prevention can be related to predictive methodologies, with focus on planning and control, while, risk adaptation can be related to adaptive methodologies, where short iterations are used to minimise impact of change.

Similar evidence was found in the literature. Complexity raises coordination challenges and thus affects the project objectives of time, cost and quality (Baccarini, 1996). These risks are mitigated by planning, coordination and control (Baccarini, 1996) as provided by predictive PM methodologies. Formal quality gates between phases of a project,
where the key stakeholder are required formally to approve the deliverables of the previous phase, ensure that risk is not carried forward from one phase to the next (Cleden, 2017) and mitigate the effect of information fragmentation, multiple objectives and goals conflicts, which are the manifestation of KNOWLEDGEST and UNCERGOAL. Up-front planning and tightly controlled processes and activities, and explicit documentation help to overcome coordination challenges generated by NUMSOC, DIVSOC and COM-PLCOMM. Up-front planning, tightly controlled processes and activities together with sequential delivery also help to manage the risks related to NUMTEC and reduce the risk of scope creep.

On the other hand, the way to mitigate risk from volatility is the use of adaptive PM methodologies. Such methodologies ensure the alignment with changing stakeholder, technologies or environment as they embrace continuous adaptation to change via lightweight processes made of fast and frequent iterations, with high reliance on tacit knowledge, high performing project teams and verbal communication (Bider, 2014). The delivery is incremental, with outputs iteratively refined in successive cycles, where mini versions of those logical work sequences are repeated.

Uncertainty is handled by retrospective reviews are used to learn lessons from one release cycle to the next (Cleden, 2017).

Essentially, it is important to ensure that the project goals are still aligned with the needs of the key stakeholders and the environment (Geraldi and Adlbrecht, 2007). Non-aligned project goals, as a result of CHANGESOC or CHANGEENV, may lead to complete project failure. Continuous adaptation to change together with retrospective reviews and frequent iterations with the key stakeholder help to keep goals aligned.

The risk of developing an obsolete solution, as a result of CHANGETEC or NOVEL-TEC, will be reduced by the fast and frequent iterations, where scope is delivered iteratively. In case of changes that make the solution no longer viable, the project failure will be reduced to the amount of resources spent during the iteration, thus, the shorter the iterations, the lower the risks.

The effects of URGENCY, where small uncertainties cause large effects, can be handled by a high performing project teams which can act flexible and independently and relies on tacit knowledge, and verbal communication.
Note that, although adaptive PM methodologies clearly help to reduce the risk of volatility, there are some downsides to these approaches. On one hand, not all projects can be split in shorter iterations, on the other hand, all iterations need to be validated, and such activities consume resources.

The outcome of my analysis is summarised in Table 2.7.

At this point, it is important to remark, that risk controls applied by the different PM methodologies with the objective to mitigate risk arising from complexity and volatility are also to be considered as decision factors in relation to the choice of PM methodologies. As discussed in Section 2.4.2, mandatory requirements from the organisation’s management or PM office (MANPMOREC), is a key factor for choosing predictive PM methodologies, while, as described in this section, team expertise (TEAMEXP), is one key characteristic of adaptive methodologies.

For that reason, both above mentioned factors will be considered in my further primary research so that to be able to separate practices related to complexity and volatility of organisational problems from those due to contextual or cultural organisational influences.

### 2.5 Summary of key findings

Our analysis of the literature has highlighted that complexity and volatility are key characteristics of today’s organisational problems, which affect project success by impacting time, cost and quality. Often conflated in the literature, the risks arising from complexity and volatility are of a different nature, hence I have introduced a distinction between complexity, as related to the presence of many interconnected parts, and volatility, as related to the likelihood of rapid change. Both can be further qualified along the dimensions of social, when related to people, technical, when related to technologies, and knowledge, when related to what is known. A set of common complexity and volatility factors have also been recognised in organisational problems and projects, which are helpful indicators of specific complexity and volatility characteristics. I will make use of both dimensions and factors in the development of my approach to hybridisation and project parametrisation.
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</tr>
<tr>
<td>Knowledge Complexity</td>
<td>KNOWLEDGEST</td>
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<td>Complete project failure</td>
<td>Formal quality gates</td>
</tr>
<tr>
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<td>Overrun of time and budget</td>
<td>Frequent, incremental iterations</td>
</tr>
<tr>
<td>Technical Volatility</td>
<td>CHANGETEC NOVELTEC</td>
<td>Produces new technical solutions and drop others into oblivion (Conklin, 2006)</td>
<td>Developing obsolescent and obsolete solution (Conklin, 2006)</td>
<td>Solution goes to waste</td>
<td>Frequent, incremental iterations</td>
</tr>
<tr>
<td>Knowledge Volatility</td>
<td>CHANGENV</td>
<td>Elements of the project are difficult to control (Lu et al., 2015)</td>
<td>High level of disorder, rework or inefficiency (Lu et al., 2015)</td>
<td>Overrun of time and budget</td>
<td>Frequent, incremental iterations</td>
</tr>
<tr>
<td>Social, Technical &amp; Knowledge Volatility</td>
<td>URGENCY</td>
<td>Increases the need of coordination and the interdependence between the project components (Williams, 1999)</td>
<td>Small problems or uncertainties cause unexpectedly large effects that may lead to greater overspend (Williams, 2005)</td>
<td>Overrun of time and budget</td>
<td>High performing project teams</td>
</tr>
</tbody>
</table>

**Table 2.7:** Manifestation of complexity & volatility, effects, impact on project success and risk controls
The presence of complexity and volatility justifies a view expressed in the literature that PM should be regarded as a form of complex problem solving. The feasibility and benefits of embedding PM within an existing problem solving framework are a key aspect of my investigation.

There is evidence that project success correlates with the choice of PM methodology, with existing methodologies each having specific means to handle project risk. At the two extreme are predictive and adaptive methodologies. Predictive methodologies put an emphasis on risk prevention and are more suitable to deal with complexity as they structure project activities and provide tightly controlled processes. Adaptive methodology put an emphasis on risk adaptation, by monitoring change constantly and ensuring that project goals remain aligned with both stakeholders and the external environment; frequent iterations and incremental delivery are their means to achieve this. In the presence of complexity and volatility, predictive and adaptive approaches are increasingly combined, although such combinations remain ad hoc and tentative, with little insight into practice. A systematic approach to hybridisation, suitably tailored to complexity and volatility, is the primary aim of my research.

In conclusion, my literature review confirms that complexity and volatility characteristics of organisational problems have an influence on the way projects are managed and on project success, the latter being also dependent on an appropriate choice and application of PM methodologies. It also reveals an increase use of hybrid PM approaches in order to deal with complexity and volatility, although both insights in today’s practice and systematic approaches to hybridisation are still lacking. These findings justify my research questions, which I will tackle in the following chapters.
Chapter 3

Methodological approach

This chapter describes and justifies the methodological approach of my research.

3.1 Research aim and questions

As stated in Chapter 1, the aim of this dissertation is to investigate the relation between organisational problem characteristics and parametrisation of PM practices, and how an existing problem solving framework, called Problem Oriented Engineering (POE, see Hall, Rapanotti, and Jackson (2008) and Hall and Rapanotti (2015)) can provide the theoretical and methodological basis for this parametrisation.

This research aim is tackled by answering the following research questions:

- Q1: How can PM concepts be interpreted in POE?
- Q2: which factors affect current choices of PM approaches made by practitioners in organisations?
- Q3: How can PM processes be parametrised based on problem characteristics?

As my research is concerned with phenomena in a social setting, i.e., the organisation, I follow the interpretive research paradigm (Oates, 2005): my aim is not to prove or disprove a hypothesis, but to analyse social processes and how human agents make sense of their perceived worlds. This paradigm is widely applied in socio-technical and information systems research, to which my research relates, and assumes that the researcher takes a reflective role, where their own assumptions, knowledge and experience shape the research process.
A mixed method approach, including both primary and secondary research, is applied in order to answer the research questions, as summarised in Table 3.1. My primary research combines quantitative and qualitative research, with the aim to look for patterns and generalisations as well as more in depth investigations (Oates, 2005). This is consistent with studies where it is not possible to establish the necessary research conditions for experimental work (Yin, 2015).

Different types of triangulation are applied in order to corroborate findings and enhance their validity (Oates, 2005), while the use of several data generation methods supports the principle that phenomena should be viewed and explored from multiple perspectives (Baxter and Jack, 2008).

In compliance with the validity criteria of the interpretative paradigm, objectivity and reliability was ensured by documenting all research procedures so that an audit trail can be carried out, while external validity was achieved by means of transferring the findings to a different organisational setting (Oates, 2005).

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Research methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: How can PM concepts be interpreted in POE?</td>
<td>Literature review and case studies</td>
</tr>
<tr>
<td>Q2: Which factors affect current choices of PM approaches made by practitioners in organisations?</td>
<td>Literature review and practitioner survey</td>
</tr>
<tr>
<td>Q3: How can PM processes be parametrised based on problem characteristics?</td>
<td>Design and creation method, based on literature review, case studies and practitioner evaluation in the form of online interviews</td>
</tr>
</tbody>
</table>

Table 3.1: Research questions and related methods

3.2 Research methods, their justification and procedures

3.2.1 Literature review

A literature review is a standard component of any scholarly work. That in Chapter 2 provided the theoretical basis for my primary research both by justifying my research questions and by contributing to specific evidence to address them.
In particular, it informed both my interpretation of POE concepts within the PM discipline (Q1, in Chapter 4), the design of my survey (Q2, in Chapter 5) and of my proposed framework (Q3, in Chapter 6) through an in-depth analysis of the academic literature related to complexity and volatility, how they manifest as source of risk during the project life cycle, and of the risk controls provided by predictive and adaptive PM methodologies.

3.2.2 Survey

Surveys allow to obtain data in a standardised and systematic way from a large number of people or events to look for patterns which can be generalised to a larger population (Oates, 2005).

In this work, I conducted a survey consisting of an online practitioner questionnaire with the objective to:

- identify factors which affect practitioners’ choices and the extent they relate to complexity and volatility, and
- gain insight into how practitioners organise their projects in response to such factors.

A standard survey design approach was followed (Oates, 2005; Fowler Jr, 2013) (see also Chapter 5). Recruiting, collecting and analysing data mostly took place digitally by means of different tools such as email, telephone, Skype, Google Forms and social media platforms. Several channels were used to reach potential participants, including professional networks, such as the CIO Forum and PMO - Project Management Office Group in LinkedIn and LinkedIn itself, where two articles outlining the research and inviting participation to the survey were published (screenshots available in Appendix B, Section B.1). Participation in the survey was entirely voluntary and anonymous, with the exception of those participants who volunteered for follow-up interviews, who were asked to provide a contact email address.

The initial survey was followed by semi-structured interviews (Oates, 2005) which gave me the opportunity to extend and cross-check the information obtained in the survey. Additionally I could get more insight into the perceived advantages and drawbacks
of the different methodologies together with information about the tools used by the practitioners to tailor project methodologies and extra requirements for new tools, which were considered when answering Q3.

3.2.3 Design and Creation Method

The design and creation method focuses on the creation of artefacts that address specific problems, together with the demonstration of the capabilities of such artefacts, and evaluation of their potential benefits and limitations (Hevner et al., 2004).

Accordingly, the main activities in the design and creation method are ‘build’ and ‘evaluate’: build refers to the construction of the artefact, while evaluate to the development of criteria and assessment of the artefact against those criteria (Oates, 2005).

The main steps are: the recognition of the problem to be solved, the suggestion of a tentative solution, the development or implementation of the tentative solution, the assessment of that solution in relation to expectations, and the derivation or consolidation of results (Vaishnavi and Kuechler, 2004). This process is expected to be iterative.

When applied to this research:

1. problem recognition was achieved through the literature review, which highlighted a view of PM as problem solving, and the lack of methodological support for the adaptation of PM methodologies and practices to complexity and volatility characteristics of organisational problems

2. a tentative solution was an interpretation of PM concepts within an existing problem solving framework, Problem Oriented Engineering (POE), to provide both a theoretical and methodological basis for PM parametrisation

3. a first step toward the development of the tentative solution was the retrospective application of this POE interpretation to a case study from the author’s professional practice, alongside the elicitation through the practitioners’ survey of knowledge related to current practice, complemented by the experience of the author as project manager of over 20 years
4. The evaluation of the proposed solution was achieved iteratively through case studies, firstly the small-scale retrospective one, followed by a more comprehensive explicative one, both from the author’s professional practice but presenting different problem characteristics in different organisations, leading to conclusions to inform the next stage of research. To complete the evaluation of the method, online interviews, where practitioners were requested to apply the method retrospectively to a complex project of their own, were conducted.

3.2.4 Case Studies

A case study is “an empirical study that investigates a contemporary phenomenon within its real life context especially when the boundaries, phenomenon and context are not clearly evident” (Yin, 2015). It is a deep analysis that takes place in its natural setting, is holistic and focuses on the complexity of the context (Oates, 2005). A theory, in the form of a new concept, framework or model can be built through case studies (Oates, 2005).

In this work, case studies were used in the context of the design and creation method just outlined to inform the development of a systematic POE-based approach to tailor PM methodologies and practices, and its evaluation.

I collected data through two real-world cases from the author’s professional practice, where projects are used to solve organisational problems presenting characteristics of complexity and volatility.

The first case study is of exploratory nature, i.e., set up to explore a situation with no clear single set of outcomes (Yin, 2003). In this case the aim was to gain an initial understanding of the application of POE concepts to PM. Data collection was retrospective, based on documentation.

The second case study was explanatory. Explanatory case studies are used to explain the presumed causal link between the implementation and the effects of a program or framework in situations which are unsuitable for survey or experimental strategies (Yin, 2003), as for example when dealing with complex social systems such as organisations, which cannot be reduced for meaningful study (Hevner and Chatterjee, 2010). In this case, the impossibility of conducting an experiment together with the limitations imposed by COVID-19 motivated the selection of a case study to evaluate the designed
framework. Data was collected by means of a diary which was filled in concurrently with the events and solely for the purpose of this task.

### 3.3 Ethical considerations

As this research involved human participants as well as organisational case studies, the OU ethical guidelines were applied with regard to informed consent and data protection. Personal data were treated in strict confidence in accordance with the Data Protection Act 2018 (GDPR).

This research has been reviewed by, and received a favourable opinion from, the Open University Human Research Ethics Committee - HREC reference number: 2908.
Chapter 4

Project Management as problem solving

In this chapter, I investigate the notion of Project Management (PM) as complex problem solving, discussed briefly in Chapter 2, Section 2.1.5, through the lens of Problem Oriented Engineering (POE, Hall, Rapanotti, and Jackson, 2008; Hall and Rapanotti, 2009; Hall and Rapanotti, 2015; Hall and Rapanotti, 2017), a framework for tackling complex real-world problems, with roots in software systems engineering. In so doing, I will address the research question:

Q1: How can PM concepts be interpreted in POE?

I will argue that this interpretation opens interesting possibilities to relate problem and project characteristics, which I will develop in the remainder of the dissertation.

The chapter is organised as follows. Section 4.1 introduces basic POE concepts. Section 4.2 argues how they may apply to PM, including consideration of risk, complexity and volatility, with Section 4.3 illustrating their practical application in a case study based on a real-world project. Finally, Section 4.4 concludes the chapter.
4.1 Problem Oriented Engineering

Problem Oriented Engineering (Hall and Rapanotti, 2017) is a framework for tackling complex real-world problems through engineered solutions, with roots in software systems engineering. POE has been applied in real-world case studies as a systematic approach to address a wide range of engineering and organisational problems (Hall, Rapanotti, and Jackson, 2008; Hall and Rapanotti, 2009), which motivated its selection in my research. At its core, POE defines both a notion of problem and of problem solving.

The POE notion of problem is derived from a traditional engineering notion (Rogers, 1983), defined as a need in context, whose solution is designed and constructed to satisfy it, where the notion of satisfaction is stakeholder dependent. The need expresses some desired outcome which has yet to be realised in the given context, which in turn imposes constraints on what is feasible: the solution must meet the need within its contextual constraints. The nature of the solution is not prescribed: it could be a system, a process, a policy, a project, or any other designed artefact.

Problem solving in POE is a process spanning both problem space and solution space, in which need, context and solution are progressively explored and validated by stakeholder in a disciplined manner: during exploration, learning takes place so that stakeholders come together to create, organise and exchange knowledge, while validation records stakeholder’ satisfaction on the outcome of exploration. The specific steps order and their duration are not prescribed, allowing for different process models and their parametrisation.

In this section I will introduce some basic POE concepts which will be used in this dissertation: there is a lot more to POE, particularly its formal definition, which can be found in Hall and Rapanotti (2017).

4.1.1 The POE process pattern (PPP)

POE defines the basic pattern of Figure 4.1 to capture the essence of POE problem solving. The pattern consists of four interleaved activities, some time taking, some instantaneous: problem exploration, solution exploration, problem validation and solution validation.
Four types of stakeholder interact with each other: problem explorers, problem validators, solution explorers and solution validators.

The aim of problem exploration is to gain knowledge of context and need. Solution exploration, on the other hand, focuses on the solution and its possible ‘architecture’.

Problem validation determines whether the characterisation of problem need and context (in the problem space) are appropriate to move on to solution exploration (in the solution space) or if further problem exploration is needed. Solution validation, instead, determines whether the explored solution is viable or if further solution exploration is needed or even if the problem needs to be revisited or explored further.

A risk model underlies the pattern: explorations take time and effort, so that expenditure and risk are accumulated during such activities, while through validation checkpoints (the diamonds in the figure), risk is transferred among stakeholders. It is worth noting that preparing for validation checkpoints, something which takes place during exploration, may also require considerable resource expenditure.

The PPP strives to provide a flexible, balanced view of problem and solution activities, for instance, to counteract tendencies to jump to solution prematurely, while still allowing for early solution consideration better to inform problem understanding. As such, it does not prescribe the order of the various activities. Instead, it gives focus to key individual stakeholder activities and their relationships, and serves as a problem solving process generator: for complex problem solving, instances of the PPP may combine in various ways, from sequential to nested, as illustrated in Figure 4.2, where PPP instances are embedded in each outer exploration activity. For instance, preparing for a validation checkpoint, can be seen as a problem solving process nested within the exploration of a customer’s problem (i.e., need in context) or solution.
The PPP is also non prescriptive of the resources (i.e., time and effort) required: the amount of problem and solution exploration needed will depend on the nature of the problem, with different problems requiring different behaviours. A complex need and context, for instance, will require a large amount of problem exploration, while complex solutions may require a large amount of solution exploration.

The relationship and timing between resource consuming problem and solution explorations and risk mitigation through validation is relevant in terms of risk management. Both problem and solution explorations commit resources to uncertain outcomes thus leading to developmental risk. A rejection by the validators, for instance, may lead either to rework in case of a rejected solution, or to a solution exploration with little chance of success in case of an invalidated understanding of the problem. In both cases there will be loss of resource. As a consequence, the more frequent the validation checks, the smaller is the accumulation of developmental risk, even though preparation for validation activities also consume resources (both time and effort) and frequent stakeholder’ engagement might be difficult to achieve in practice.

In the end, the process will be shaped by the various trade-offs between the learning generated during exploration and the risk reduction as a result of validation, with the following adjustments possible to parameterise a process:

1. the timing of the iteration between problem exploration and problem validation can be varied;
2. the timing of the iteration between solution exploration and solution validation can be varied; and

3. the timing of the iteration between problem exploration and solution exploration can be varied.

### 4.1.2 Problem models

The three elements of a POE problem, need, context and solution, are expressed in terms of their phenomena, following Jackson (2001)’s definition of phenomenon as:

> an element of what I can observe in the world. Phenomena may be individuals or relations. Individuals are entities, events, or values. Relations are roles, states, or truths. ((Jackson, 2001), Page 273)

POE does not prescribe any specific language to express phenomena, nor their level of abstraction. Phenomena can be very simple, so that they cannot be broken down into simpler phenomena, or complex, representing collections of interacting phenomena, the latter referred to as domains (Hall and Rapanotti, 2017). They can be expressed formally, in mathematical language, or informally, in natural language. The appropriate level of abstraction and type of language will depend on the nature of the problem and domain of application. In the case of an organisational problem, phenomena will relate to elements of the organisation which are meaningful to its stakeholder, and natural language is the more likely type of description language used, as is the case in this dissertation.

Here is a simple illustrative example. Let us assume that Carolina, who owns and runs a small company, needs to ‘register and compute every tax relevant transaction in order to be able to fill in her tax declaration, in a way which is compliant with the tax agency’s guidelines’. Carolina’s need makes reference to a number of phenomena: entities such as tax relevant transactions and a tax declaration, and events such as registering and computing transactions, and filling in the tax declaration. As I do not need to understand their details, Carolina’s small company and the tax agency can be considered as domains, making up the problem context. Such domains interact by sharing phenomena: the tax agency issues forms and guidelines, and receives filled-in tax declarations from Carolina’s company.
Carolina has many choices as to how to solve her problem. She may consider different possible solutions, such as: booking all transactions by hand, or employing an accountant, or buying an off-the-shelf tax software system, or develop such a system in house. In the end, her choice will be a trade off between different constraints like time, cost, effort, or availability of an off-the-shelf solution. In this example, let us assume she decides to acquire a solution in the form of an off-the-shelf tax software system: this too can be seen as a domain, interacting with the other domains in the problem. The resulting (solved) problem is captured graphically by the problem diagram (Nkwocha, Hall, and Rapanotti, 2010) in Figure 4.3, where domains (rectangles) are represented with their shared phenomena (on arrows between rectangles). The ‘!’ symbol comes from the Problem Frames notation (Hall and Rapanotti, 2017) and is used to indicate which domain ‘controls’ the phenomena. For instance, the expression ‘TA!(forms, guidelines)’ indicates that domain Tax agency controls both forms and guidelines phenomena.

**Figure 4.3**: Carolina’s “tax declaration problem” as a POE problem diagram
As noted in the example, domains interact through their shared phenomena. More formally (Hall and Rapanotti, 2017), based on their relation to a domain $D$, phenomena can be categorised as: controlled by $D$; observed by $D$, if shared but not controlled by $D$; and unshared by $D$, if neither controlled nor observed by $D$. For instance, in the figure, forms and guidelines are controlled by the Tax agency domain and observed by the Tax software domain.

A domain $D$ is formally defined (Hall and Rapanotti, 2017) as a set of controlled phenomena together with a description of the domain’s indicative, or known, properties, i.e., how its controlled phenomena interact with each other and those that it observes in its environment (its observed phenomena). Therefore, a domain names and describes a mechanism that relates phenomena.

The problem need is the description of a wish expressed in phenomena. The phenomena affected by the need will delimit the scope of the domains and the phenomena relevant for the specific problem within the context. Phenomena can be referenced by a need description or constrained by a need description, i.e., those phenomena that the solution domain’s behaviour may influence as a solution to the problem. In the example, the need refers the tax agency’s guidelines and constrains the filled-in tax declaration to be compliant with them.

Once the problem is solved, the solution domain and its phenomena become part of the context, and may be the starting point to formulate other problems. The solution will constrain phenomena in accordance with the constraints introduced by the need, although it may also add further constraints. For instance, in the example, the need was to ‘register and compute every tax relevant transaction’ with the software solution dictating a particular way for this to happen.

### 4.1.3 Problem transformations

Problem solving in POE proceeds through formally defined problem transformations (Hall and Rapanotti, 2017) used to transform problems into others as I progress towards solution during the problem solving process. An example from Hall and Rapanotti (2017) is reproduced in Figure 4.4, which captures the formal process of providing a software solution, $S$, for Jon, who ‘wishes to be alerted when the weather forecast predicts rain in
his area’ (SDNeed). The tree is the result of transformation steps from the initial problem at the bottom (the root), to the problem at the top (the leaf).

\[
[W\text{Stat}, i\text{Pad}] \vdash_{\text{IRTA}} \text{SDNeed} \quad \text{[IRTA Tested to Jon’s satisfaction]}
\]

\[
[W\text{Stat}, i\text{Pad}] \vdash_{\text{Jon}} \text{SDNeed} \quad \text{[Apply solution interpretation with [S/IRTA]]}
\]

\[
[W\text{Stat}, i\text{Pad}] \vdash_{\text{Jon}} \text{N} \quad \text{[Apply Need Interpretation [N/SDNeed], found in consultation with Joe]}
\]

\[
E(S) \vdash_{\text{Jon}} N \quad \text{[Apply Environment Interpretation [E/[W\text{Stat}, i\text{Pad}]], found in consultation with Jon and by inspection of the environment]}
\]

FIGURE 4.4: Example of a formal POE tree (reproduced from Hall and Rapanotti (2017))

Hall and Rapanotti, 2017 defines a full logical calculus, but this is beyond the scope of the dissertation: it has, however, been used in real-world engineering applications of POE (e.g., Hall, Mannering, and Rapanotti, 2007). Instead, in this work I will use an alternative graphical representation, similar to that in Figure 4.5 as per the formal notation, the root problem is at the bottom (P1 in the figure) and the leaf problems at the top (P4.1 and P4.2 in the figure). In this example the branch to the right represents the failed process to solve problem P2, which had to be backtracked due to failure to validate the solution of sub-problem P2.1. I will cover the graphical notation in more detail in Section 4.3.

FIGURE 4.5: Example of a graphical POE tree (reproduced from Nkwocha, Hall, and Rapanotti (2010))

In this section, I only discuss POE transformations in general terms, relevant to their practical application to real-world organisational problems. In essence, POE problem
transformations are used to record how knowledge of the various problem elements changes during problem solving, as well as to record evidence and outcomes of stakeholder validation.

The key formal transformations defined in Hall and Rapanotti (2017) allow us to transform problems as a result of exploration activities by:

- replacing one description of a problem element for another, including adding structure to context or solution domains (interpretation),

- decomposing problems into sub-problems once a solution 'architecture' has been established (solution expansion), so that solutions to sub-problems can then be recomposed via the architecture,

- replacing validating stakeholder, based on organisational roles, influence or other significant relationships (substitution).

In order to define a solution architecture, solution interpretation makes use of AS-structs, each defining a solution structure in terms of existing and to-be-designed components and their interdependencies. A subsequent decomposition (via expansion) allows the definition of sub-problems to design the new components in a way which is compatible with the whole architecture. Examples of software solution architectures are provided in Hall and Rapanotti, 2017.

POE transformations come with justification obligations, which can only be discharged if the transformation they guard is validated by the relevant stakeholder. Successful validation indicates that the stakeholder are satisfied that the step taken is adequate: this is consistent with Herbert Simon’s notion of satisficing (Simon and March, 1976) as a decision-making process that strives for adequate rather than perfect results.

Note that the construction of justification obligations may be, in itself a problem solving process. This can be seen, for instance, in applications of POE to safety critical systems engineering, where justification obligations can be as extensive as performing a full system safety analysis (Mannering, Hall, and Rapanotti, 2008) or constructing safety cases Hall and Rapanotti, 2009. In this work, it relates to the definition of project architectures.
4.1.4 Tangled problems and naive decomposition

When two or more problems are expressed in terms of the same phenomena, they are said to tangle (Hall and Rapanotti, 2017). Examples of tangled problems can be observed in many real-world situations, including dealing with organisational problems.

When problems tangle, care must be taken during problem solving as the solution to one problem may constrain phenomena in a way which makes the solution of the other problems unfeasible. Therefore, in the presence of tangled problems, a divide-and-conquer solution strategy may be too naive and increase the risk of failure, so called naivity risk (Hall and Rapanotti, 2017).

In the ‘tax declaration problem’ example, the solution chosen by Carolina could have had an impact on unsolving other problems. Let’s assume, for instance, that the software bought by Carolina is extremely expensive and her small company cannot afford it. In such case, spending so much money on the software would prevent her from doing the necessary investments to keep her business running and even put the survival of the small company at risk. Money would be, in this example, the phenomenon shared by both the tax declaration problem and running the company.

Mainly, naive decomposition may occur during problem solving when decomposing a problem into sub-problems: if those sub-problems tangle, then it may be necessary to co-design (Hall and Rapanotti, 2017) their solutions in order for solution recomposition to be successful. Basically, tangled problems are problems whose phenomena relationships are such that their naive decomposition into separate (sub-)problems is unlikely to lead to an overall successful solution.

4.1.5 Organisations as tangled solutions

Towards the end of Section 4.1.2, I noted that once a problem is solved, its solution becomes part of the context of future problems yet to be solved (Markov, Hall, and Rapanotti, 2016). In the event that the context consists of an organisation, it follows that, at any point in time, the organisation can be seen as the tangle of all the solutions to organisational problems solved over time. This provides a POE notion of organisational
change, as a continuous process of satisfying new needs in a progressively changing organisational context: as new needs emerge, the organisational tangle changes with, for instance, new solutions weaved in, or obsolete solutions phased out or replaced.

This view is consistent with Rittel and Webber (1973)'s view of organisations as consisting of social processes as links which tie systems into larger ones “such that outputs from one become inputs to others”.

### 4.2 Interpreting Project Management within POE

As indicated in Chapter 2, p. 7, the Project Management Institute (PMI) defines a project as “a temporary endeavor undertaken to create a unique product, service or result,” which aligns well with the POE notion of problem solving when applied to organisations, i.e., that of addressing a specific need within an organisational context through the design of artefacts. In this section I consider how to interpret key PM concepts within POE.

#### 4.2.1 Key concepts in Project Management

The PM Book of Knowledge (PMBOK) (Project Management Institute, 2017a) provides the key definitions summarised in Figure 4.6.

<table>
<thead>
<tr>
<th>PMBOK* Guide Key Component</th>
<th>Brief Description</th>
</tr>
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<tbody>
<tr>
<td>Project life cycle (Section 1.2.4.1)</td>
<td>The series of phases that a project passes through from its start to its completion.</td>
</tr>
<tr>
<td>Project phase (Section 1.2.4.2)</td>
<td>A collection of logically related project activities that culminates in the completion of one or more deliverables.</td>
</tr>
<tr>
<td>Phase gate (Section 1.2.4.3)</td>
<td>A review at the end of a phase in which a decision is made to continue to the next phase, to continue with modification, or to end a program or project.</td>
</tr>
<tr>
<td>Project management processes (Section 1.2.4.4)</td>
<td>A systematic series of activities directed toward causing an end result where one or more inputs will be acted upon to create one or more outputs.</td>
</tr>
<tr>
<td>Project Management Process Group (Section 1.2.4.5)</td>
<td>A logical grouping of project management inputs, tools and techniques, and outputs. The Project Management Process Groups include Initiating, Planning, Executing, Monitoring and Controlling, and Closing. Project Management Process Groups are not project phases.</td>
</tr>
<tr>
<td>Project Management Knowledge Area (Section 1.2.4.6)</td>
<td>An identified area of project management defined by its knowledge requirements and described in terms of its component processes, practices, inputs, outputs, tools, and techniques.</td>
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</tbody>
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**Figure 4.6**: Key definitions (reproduced from Project Management Institute, 2017a)
The project life cycle is “the series of phases that a project passes through from its start to its completion,” with those associated with the development of the expected scope seen as representing the development life cycle.

Each phase is a collection of time bound project activities performed with the objective to complete one or more deliverables: its characteristics, e.g., duration or activities perform, are specific to the nature of the project and the level of control required by the organisation. At start, end and specific control points, phase reviews (a.k.a. gates) allow stakeholders to review progress.

Activities within a project and its phases relate to one of five Project Management Process Groups (Project Management Institute, 2013):

- **Initiating**, with activities to obtain authorisation to start a new project or a new phase of an ongoing project.

- **Planning**, with activities to establish the scope of the project/phase, refine its objectives and define a course of action to meet them.

- **Executing**, with activities to complete the project/phase work and deliver the scope.

- **Monitoring and Controlling**, with activities to track, review project/phase performance to identify, approve and initiate needed changes to the project plan.

- **Closing**, which finalises all activities across all process groups to close the project or phase formally.

Within each group, the PMI defines specific activities with reference to a number of PM knowledge areas, as summarised in Figure 4.7 with data flowing between activities as input or output. For instance, within the Initiating Process Group activities will take place to develop the project charter, which is an input to several activities belonging to other process groups, such as the development of the project management plan or the definition of the project scope, as shown in Figure 4.8 which provides the detail of the corresponding data flow.

The relationship between project life cycle, process groups and knowledge areas is exemplified in Figure 4.9: the project life cycle is organised in phases with specific gates in between (top of the figure); each phase will include activities belonging to (some or
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<tr>
<td>4. Project Integration Management</td>
<td>4.1 Develop Project Charter</td>
<td>4.2 Develop Project Management Plan</td>
<td>4.3 Direct and Manage Project Work</td>
<td>4.5 Monitor and Control Project Work</td>
<td>4.7 Close Project or Phase</td>
</tr>
<tr>
<td>5. Project Scope Management</td>
<td>5.1 Plan Scope Management</td>
<td>5.2 Collect Requirements</td>
<td>5.3 Define Scope</td>
<td>5.4 Create WBS</td>
<td>5.5 Validate Scope</td>
</tr>
<tr>
<td>6. Project Schedule Management</td>
<td>6.1 Plan Schedule Management</td>
<td>6.2 Define Activities</td>
<td>6.3 Sequence Activities</td>
<td>6.4 Estimate Activity Durations</td>
<td>6.5 Develop Schedule</td>
</tr>
<tr>
<td>7. Project Cost Management</td>
<td>7.1 Plan Cost Management</td>
<td>7.2 Estimate Costs</td>
<td>7.3 Determine Budget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Project Quality Management</td>
<td>8.1 Plan Quality Management</td>
<td>8.2 Manage Quality</td>
<td></td>
<td></td>
<td>8.3 Control Quality</td>
</tr>
<tr>
<td>10. Project Communications Management</td>
<td>10.1 Plan Communications Management</td>
<td></td>
<td></td>
<td>10.2 Manage Communications</td>
<td></td>
</tr>
<tr>
<td>11. Project Risk Management</td>
<td>11.1 Plan Risk Management</td>
<td>11.2 Identify Risks</td>
<td>11.3 Perform Qualitative Risk Analysis</td>
<td>11.4 Perform Quantitative Risk Analysis</td>
<td>11.5 Plan Risk Responses</td>
</tr>
<tr>
<td>12. Project Procurement Management</td>
<td>12.1 Plan Procurement Management</td>
<td></td>
<td></td>
<td>12.2 Conduct Procurements</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4.7:** Project Management Process Groups and Knowledge Areas mapping (reproduced from Project Management Institute, 2017a)
all of) the five defined process groups (middle of the figure), with activities pertaining to specific knowledge areas (bottom of the figure).

For each project, the PM team will determine the most appropriate life cycle, adjusting the attributes of each phase, e.g. its duration, or entry and exit criteria, which processes should take place, their iterations and interactions. Some processes, such as developing the project charter or closing the project, may only occur once or at predefined points in the project; other processes, such as defining activities and acquiring resources, may be performed periodically; other processes may still be continuous, like monitoring and control processes. Such decisions belong to the Project Integration Management Knowledge
Area, and will be influenced both by project and organisational needs, and by method-ological choices. Developing ways to inform these decisions systematically is one of the aims of this research.

4.2.2 A POE interpretation of Project Management key concepts

As instruments by which solutions are produced, projects work within the organisational context towards meeting organisational goals. As such, they can be seen as problem-solving activities.
solving activities and, hence, are characterisable in POE. In this characterisation, I find it useful to distinguish between:

- the *organisational problem*, which requires addressing a specific organisational need, and

- the *project problem*, which requires organising the project to deliver the solution to the organisational problem.

The solution to the former (should one exists) is an artefact satisfying the specific organisational need, while that of the latter, is the project life cycle itself. In terms of project management, I can relate the former to the deliverables of the project life cycle phases, and the latter to the way the project is managed through the organisation of its activities, i.e., the *project architecture* with its phases, phases attributes and corresponding PM processes.

I establish a link between project life cycle and POE by interpreting each phase in a project life cycle as a problem solving process in its own right, as follows:

- ‘Starting the project’ is a problem solving activity to address the need to collect sufficient information to decide whether the project should proceed within the organisational context. It includes two sub-problem activities, that of developing the project charter and of identifying the project stakeholder, each leading to solution artefacts: the project charter itself, issued by the project initiator or sponsor to formally authorise the project; and the stakeholder register, which helps to identify stakeholder with a particular interest in, or impact on, the project. The approved project charter, part of the validated solution, becomes the precondition for the next project phase. Note that this phase can be quite complex, with potentially many partial problem and candidate solutions evaluated, by problem owners and solution owners in collaboration with the problem solvers (e.g., the project team), with a project steering committee validating the project charter. Also a baseline performance will be established, to be monitored throughout the project, possibly via a control body such as the PM Office.

- ‘Organising and preparing the project’ has the project charter within its context, that is the output of the previous phase: in POE terms, the project charter establishes
the initial assumptions for the project, on which this phase relies upon. The need is to define a detailed project plan, including specific quality, resources, communication, risk responses, procurement, stakeholder engagement plans, and a work-breakdown structure, schedule and budget. The approved project management plan, the validated solution, is the precondition for the next project phase.

- ‘Carrying out the work’ satisfies the need to deliver the scope, within the constraint of the project plan developed. This is the most complex problem solving phase, corresponding to the development life cycle of the project, so that it will include many sub-problems, related to the management of quality, resources, communications, risk responses, procurement and stakeholder and the issuing of approved changed requests and project plan updates. The solution consists of the project deliverables, with their acceptance (validation) the precondition for the next project phase.

- ‘Closing the project’ has the validated deliverables within its context, and addresses the need to close all open project activities, possibly re-allocating remaining resources to other projects or tasks, evaluating the performances of teams and of the vendors and documenting all issues which may be relevant for future projects. Its solution consists of the final report, the transition of the final product or service and the archived documents.

A summary of my POE interpretation of the four life cycle phases is given in Figure 4.10 where the life cycle proceeds from one phase to the next once the established precondition is met. In this summary representation, I make no attempt to break down each phase into its process groups and activities, but only note that each phase is a full PPP cycle which will be decomposed as needed on a project by project basis. Investigating how this can be achieved systematically, informed by characteristics of the organisational problem is the core contribution of this work.

4.2.3 Characterising different project life cycles

In Chapter 2 I observed how predictive PM methodologies favour sequential delivery, while adaptive methodologies an incremental one, hence accomplishing the scope in a different manner, which affects the way processes and activities are organised within
Figure 4.10: Projects as a collection of problem solving activities

the project life cycle. PMI characterises different PM methodologies according to how process group activities are distributed along their development life cycle along the continuum captured in Figure 4.11, from predictive (plan-driven), to iterative, incremental and adaptive (agile).

At one extreme, predictive project life cycles emphasise the specification of requirements and detailed planning during the early phases of a project, with risk mitigation and cost control achieved through detailed planning based on known requirements and constraints. Key stakeholder are involved at planned milestones. During the execution of the detailed plan, the monitoring and controlling processes constraint any changes that might impact the scope, schedule, or budget.

Fully adaptive (agile) life cycles, at the other extreme, progressively elaborate requirements based on short iterative planning and executing cycles. The progressive evolution of the initial plans reduces risk and cost delivering better quality and responding to changes more quickly through the continuous involvement of key stakeholder.

Somewhere in between, iterative and incremental life cycle combine characteristics of
the two extremes by using planned iterations to evolve the project plans in a controlled manner, involve key stakeholder regularly, and deliver the scope incrementally.

Based on the POE interpretation of a project life cycle I discussed in the previous section, it is possible to provide PPP models corresponding to different PM methodologies. Examples of how this can be done are provided in Hall and Rapanotti (2015), which focuses on software engineering methodologies. In that work, different software development processes are modelled through the PPP. This modelling is based on descriptions of process models from the literature, and takes into consideration characterisations of activities and information flow, and relationships between actors. It is based on the idea that each stage in a process can be interpreted as an instance of the PPP, where the presence and/or extent of each PPP activity will depend on the specific methodology. For instance, a PPP interpretation of SCRUM, which is a specific PM method applied to software development, is captured by Figure 4.12.

Briefly, in SCRUM the emphasis is on the product rather than the project and there is no explicit notion of PM, although product development is clearly managed. In particular, product development is carried out in time-boxed iterative and incremental cycles called sprints, which are planned by a Product Owner able to identify and prioritise which product features should be developed in each sprint. This is captured in the so-called Product Backlog, which is the input to each sprint’s planning meeting and is updated during the
sprint reviews afterwards to inform the following sprint. A cross-functional co-located development team, enabled by a ScrumMaster, is responsible for the development of a “potentially shippable product increment” after each sprint.

It is worth noting that Hall and Rapanotti (2015)’s approach is consistent with my interpretation of projects as problem solving activities which can be related to a project life cycle, its phases and process groups, as well as the PMI characterisation of different PM methodology along the continuum of Figure 4.11.

4.2.4 Complexity and volatility in POE

As discussed in Chapter 2, complexity and volatility are key characteristics of organisational problems that projects need to deal with. I recall that in this work I adopt a notion of complexity as related to the presence of many interconnected parts which may interact in complicated or unpredictable ways, and of volatility, as related to the likelihood of change, possibly rapidly and unpredictably. Moreover, both for complexity and volatility, I distinguish the three dimensions of social (when related to people and their norms and cultural aspects), technical (when related to systems, structures and technologies) and knowledge (when related to what is known in the form of distributed, tacit and non-codified knowledge).

Given that POE problems are expressed in terms of phenomena and their relationships, in this work I see problem complexity and volatility as related to those phenomena and their relationships. Moreover, given that a POE problem is made of three distinct
parts (i.e., need, context and solution), those phenomena can be located within each of them, with sharing as a way to capture how they influence different parts of a problem. Validation brings complexity and volatility as well, through the number of validating stakeholders and their, possibly shifting, expectations and relationships.

The further qualification into social, technical and knowledge still applies. However, as POE domains capture complex sets of phenomena, such a distinction is not always possible at domain level: domains are more likely to be of a mixed nature, often socio-technical, aggregating phenomena which capture the interaction between people and technology, and with elements that may change at different rates. As a consequence, the complexity and volatility factors considered in Chapter 2 Section 2.2.3 may be apparent in all parts of a POE problem.

As the main focus of this dissertation is to investigate how complexity and volatility in problems affect the problem solving process, I will make use of this interpretation of complexity and volatility within POE throughout the dissertation.

4.3 Case study

I conducted an exploratory case study as a first test of the ideas introduced in this chapter. In particular, I applied my interpretation of PM concepts within POE to a real-world project retrospectively in order to:

- test my POE interpretation of PM concepts against real-world PM artefacts, processes and practices;
- explore the relationships between problem transformations and activities within project phases;
- explore the extent phenomena in problem models can be used to assess complexity and volatility.

The author was a member of the project team and had access, with permission from the organisation, to project documentation and other team members and project stakeholder.
4.3.1 The organisational problem

The project under study took place in the context of an international corporation and was aimed at delivering a new IT system for the validation of partner data in its subsidiaries. The name of the companies involved has been anonymised, so that I only refer to them as Companies A and B.

Company A was a division of Company B, who owned it, and was itself a multinational company with many subsidiaries. Company B owned a system which implemented a global partner master data validation process in order to enforce compliance in all its divisions and subsidiaries, including Company A. The project was triggered by a change in international strategy by Company B, who decided to start an initial public offering in order to turn Company A into an independent company listed on the stock exchange. This required the separation of their processes and IT systems, including that for partner data validation.

This problem is an example of a complex IT/business alignment problem in which changes in an organisation’s international strategy entail changes in organisational structures, processes and systems (Madapusi and D’Souza, 2005), with IT projects becoming facilitators or even drivers for the change (Kelzenberg, Wagner, and Reimers, 2011).

As Bartlett and Ghoshal (1999) point out, such projects require coordination and integration among dispersed organisational units as the IT infrastructure needs to support extended business processes (Hunter, 2009) which enable data visibility and transactional interoperability on a global scale (Shiang-Yen, Peng, and Idrus, 2014). Such projects also need to deal with the interests of a large constituency of stakeholder, often with conflicting goals (Artto et al., 2008), so that collaboration can be a particular challenge as team members from various subsidiaries have priorities and interests that differ from those of the central team (Klimkeit, 2013). In this case study, the project team included 40 international members belonging to the corporation and its subsidiaries.

I was the project manager in charge of the complete implementation. The project duration was 18 months and was ultimately successful in providing a stable and well-accepted solution, but it did required costly rework as I will discuss.
4.3.2 Overview of the project

The Board of Company A decided to adopt a partner validation process at least as compliant as the one provided by Company B. A feasibility study was conducted to explore different solutions to this problem, estimate costs, benefits and timeline. Once a candidate solution was selected, a project team was put together in order to implement it, although changes to both plan and scope were necessary later on. Table 4.1 summarises the different candidate solutions considered, the key validating stakeholder and the reason for their rejection or acceptance. The validating criteria applied by the validators are summarised in Table 4.2 which were the source of goal conflicts leading to project changes.

<table>
<thead>
<tr>
<th>Organisational Problem</th>
<th>Candidate solution description</th>
<th>Validating stakeholder</th>
<th>Reasons for approval or rejection</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Buy service for a fee from Company B</td>
<td>Board</td>
<td>Rejected due to high costs and no additional benefits</td>
</tr>
<tr>
<td>P2</td>
<td>Develop bespoke central application, with harmonisation of processes and data</td>
<td>Board, Budget holder, IT architect</td>
<td>Accepted as providing additional benefits such as data transparency. During implementation, however, lack of validation from subsidiaries’ stakeholder, who requested additional requirements, forced a review of project scope and budget</td>
</tr>
<tr>
<td>P3</td>
<td>Augment the bespoke central application with a data converter for data entered centrally according to the subsidiaries’ configurations</td>
<td>Board, IT architect</td>
<td>Rejected due to high costs and risks to keep conversion tables synchronised</td>
</tr>
<tr>
<td>P4</td>
<td>Within the bespoke central application, separate functions for data and process harmonisation relevant to partner data validation, from data and processes to be adapted to local requirements</td>
<td>Board, Budget holder, IT architect, Subsidiaries’ stakeholder</td>
<td>Accepted as providing a trade-off between data transparency and keeping changes to subsidiaries’ systems and processes to a minimum</td>
</tr>
</tbody>
</table>

Table 4.1: Solution alternatives to the organisational problems

4.3.3 PPP characterisation

Figure 4.13 provides a PPP model of the whole project from the feasibility study to the delivery of the final solution. It captures each significant project step as a PPP activity, including those related to organisational problems and those relate to the project problems.
Table 4.2: Validating stakeholder criteria

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Validation criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board of Company A</td>
<td>Keep the same compliance level as provided by the existing solution in Company B while minimizing costs</td>
</tr>
<tr>
<td>IT architect</td>
<td>Implement a stable solution while minimizing costs</td>
</tr>
<tr>
<td>Budget holder</td>
<td>Obtain a stable solution while minimizing costs, and with additional benefits from process harmonisation, e.g., global transparency</td>
</tr>
<tr>
<td>Subsidiaries’ stakeholder affected by the solution</td>
<td>Be compliant to what is required by the Board with minimal changes to local systems and processes</td>
</tr>
</tbody>
</table>

To distinguish them, I have used labels P1, P2, etc. for organisational problems, and labels PP1, PP2, etc. for project problems, with numbering providing the correspondence between the two: for instance PP1 is the project problem associated with P1. All problem details are provided in Appendix A.

In the figure, I have used the prefix PE as a shorthand for Problem Exploration and SE for Solution Exploration: for instance the problem exploration of problem P1 is indicated as PEP1. The figure also indicates where validation failed, with a red cross in the corresponding validation diamond, highlighting where the process had to backtrack and resources were wasted.

The relation between organisational and project problems is captured in this figure. Problem solving started with P0, where the need to keep the same compliance level as provided by Company B and while minimizing costs in the context of Company A, subsidiary X, subsidiary Y, ERP X, ERP Y was explored. This exploration resulted in the interpretation of the need and led to P1. In P1 the first candidate solution (to buy services for a fee from Company B) was identified, motivating PP1 which explored the feasibility of implementing the first candidate solution. In PM terms, PP1 corresponds to the ‘starting the project’ phase. While PP1 succeeded in delivering the feasibility assessment, this candidate solution was rejected as the fees requested by Company B were considered too high, so that SEP1 was not validated.

This led to P2 and the second choice of candidate solution, which was to develop a new bespoke central application for data and processes across all subsidiaries. PP2 was set up in order to evaluate this alternative, with planning in PP2.1, and the work carried...
Figure 4.13: PPP model of the project, including visualisation of sunk costs
out sequentially in PP2.2 and PP2.3. However, the deliverables, i.e., the implemented candidate solution, were not accepted by the affected subsidiaries’ stakeholder, so that the effort spent in PP2, PP2.1, PP2.2 and PP2.3 went to waste.

This led to P3, with proposed changes to the implemented system proposed as a new candidate solution. After a feasibility assessment in PP3, this too was rejected and thus a new candidate solution was considered (P4) and evaluated in PP4. After the successful evaluation, work was planned (PP4.1) and then carried out (PP4.2, PP4.3 and PP4.4), until all project activities were closed in PP4.5, thus solving P4 and addressing the original organisational problem P0.

In this representation, as well as visualising the different organisational problems and project problem steps, I also visualise when resources were consumed in activities, including those which were subsequently not validated. The solution alternatives evaluated in P1 and P3, for instance, were rejected in early validation steps so that only the resources spend during the initiating phase in both cases went to waste and, as a consequence, the sunk costs were relatively low. Rejection at early steps was possible because all relevant validators were included in early validation. The candidate solution chosen in P2, however, was rejected at a much later stage (after PP2.3) because key subsidiaries’ stakeholders were not included early enough and could not assess the impact of the proposed solution until the software was tested, thus the sunk costs were high.

### 4.3.4 Problems and design trees

I have captured each significant project step as a POE problem, separating organisational and project problems, with the full account provided in Appendix A: each problem corresponds to a row in the spreadsheet provided. For instance, those corresponding to P0, P1 and PP1 are reproduced in Table 4.3.

The first two columns indicate, respectively, organisational or project problem labels, and for the latter the related project life cycle phase. Next are the POE elements of each problem, including need, context, solution, their validators and related validation status, with √ indicating successful validation, and X unsuccessful validation.

The design tree for the whole case study is depicted in Figure 4.14, where I have adopted the following notation. The design tree for organisational problems is given
<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project problem</th>
<th>Phase (project problems only)</th>
<th>Status problem validation</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status solution validation</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td></td>
<td>√</td>
<td>Board</td>
<td>Keep same compliance level as provided by the initial solution while minimising costs</td>
<td>Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td></td>
<td>√</td>
<td>Board</td>
<td>N1: to be able to validate partner master data</td>
<td>Company B, CMD B, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y, fees</td>
<td>X</td>
<td>Board did not approve to continue with the alternative due to the fees</td>
<td>BoardX</td>
<td>Buy services from company B</td>
</tr>
<tr>
<td>PP1</td>
<td>Initiating</td>
<td>√</td>
<td>Board</td>
<td>Explore feasibility to continue with current solution provided by company B and pay fees for the service</td>
<td>Company B, CMD B, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y, fees</td>
<td>√</td>
<td>Board</td>
<td>Feasibility explored</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.3: Extract from Appendix A**
to the left, while to the right I have indicated the corresponding project problems. All labelling corresponds to that in the spreadsheet in the appendix. Successful and unsuccessful validation of organisational problems is indicated with green ticks and red crosses respectively, with dotted arrows indicating when backtracking has taken place following unsuccessful validation. Project problems are colour-coded according to life cycle phases.

**Figure 4.14:** Design tree with an indication of both organisational and project problems

Consistently with the PPP model in Figure 4.13, N1, the need in P1, is validated and
the proposed solution S1, that of buying services from company B, is explored via a feasibility study in the project space, captured as PP1. While PP1 succeeds as a feasibility study, the solution S1 to P1 is rejected by the Board as the study indicates that the fees requested by Company B were too high.

As per all POE problems, each problem can be modelled using a problem diagram, as exemplified in Figure 4.15 for P1, which provides the detail of all the phenomena and domains involved, and their sharing.

![Diagram of problem P1](image)

**Figure 4.15:** Unsolved problem P1, expressed as a problem diagram, showing relevant domains and phenomena

### 4.3.5 Problem transformations and project phases

While P1 was not transformed any further, given the lack of solution validation following the feasibility study in PP1, a different story can be told about P2, with the corresponding life cycle covering both initiating and planning and executing phases. In this case, P2 underwent various transformations as a result of solution exploration activities.

The initial P2 problem model is captured in Figure 4.16, which indicates that a new bespoke system MDG A is to be designed and developed to interact with the subsidiaries’
systems as indicated in the figure.

Solution exploration via the related project phases leads to the initial design of MDG A is captured in Figure 4.17

However, during implementation, at step PP2.3, where the solution was tested by the subsidiaries, its impact on the context became evident, leading to its rejection. The problem diagram, which shows the impact on the subsidiaries’ systems is given in Figure 4.18

4.3.6 Technical complexity

In the problem transformations from Figure 4.16 to 4.17 and finally to 4.18 I can see how technical complexity becomes more and more apparent as detail is added to the solution design. In particular, the last model clearly indicates which domains in the subsidiaries would have to change due to phenomena shared with the designed solution, as well as
Chapter 4. Project Management as problem solving

Figure 4.17: P2 problem model, with initial solution design

the scope of the required change, which, in turn, gives some indication of the required development effort and potential risk. It also points to the fact that the affected stakeholders (the subsidiaries) should have been involved in validating the candidate solution from the very start.

In the live project such an analysis was not performed, so that the impact only became apparent once the software had already been developed and was being tested. I could speculate that this type of analysis before starting any development activity could have led to a better choice of validating stakeholder and reduced waste of development resources.
Satisfied need: use MDGA to process, approve and validate partner master data records and then transmit them to ERF X and Y for further usage in transactions.

Impact of the solution:
MDGA has an interface to ERF X and ERF Y, where a master data record is replicated (data). This phenomenon is restricted by the configuration of approval steps and master data tables. This restriction includes:
1) A specific number range
2) Specific context according to the list of values and mandatory and optional fields
3) It is already validated according to the configured approval steps.

These phenomena are shared by MDGA, MDX and MDY. MDX and MDY need to process partner master data for transactions TX and TY, both transactions and MDX and MDY receive the global partner master data from MDGA. To make it possible that global partner master data can be processed in transactions TX and TY, MDX, MDX, TX, MDX and TY need to change. Changes in TX and TY were not accepted by SK, SY due to the high risk to incorrect operations in case of not identifying all necessary changes and related costs to adapt programmer affected by the change and redundant testing to minimize the risks.

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**Figure 4.18: P2 problem model, context and solution interpretation - not considered at project approval**
4.3.7 Discussion

In this section I evaluate critically the case study work in relation to its three main objectives.

POE interpretation vs real-world processes and practices  The exploratory case study demonstrated that my POE interpretation of PM concepts is plausible in its application to real-world projects.

The problem elements, detailed in the spreadsheet in Appendix A were able to capture all key elements of the real-world project: from the definition and characterisation of the organisational problem to the different project phases, including the identification of affected stakeholders.

By applying the PPP, I was able to model all significant project activities as POE problem solving processes, including stakeholder involvement in validation activities and their outcomes. As a consequence, I was able to provide an indication of where development risk was accumulated and the extent of related sunk risk when candidate solutions were rejected by stakeholders.

The association of project problems and project life cycle phases gave me an indication of how the project was organised in terms of phases, the characteristics of such phases, and the type of processes executed in each. This association is one I will investigate further and exploit in the dissertation.

The use of problem diagrams in the case study indicated that they can provide suitable models for the analysis of complexity, in particular technical complexity: they enabled a structured analysis of the technical landscape and organisational context, with phenomena helping in the identification of sources of complexity and problem tangles. The extent they can help with other complexity dimensions and with volatility is something for further exploration in this dissertation.

Relationships between problem transformations and project phases  The enhanced design tree notation I introduced allowed me to separate, but still relate design problems and their project activities, and to investigate project structures in relation to design
problems characteristics and problem transformations. For instance, subsequent interpretations of the need, as in P1, P2, P3 and P4, had an impact on the architecture of the project problem steps: every time the need changed, a starting phase step needed to be executed in the project.

However, this notation does not include any indication of complexity and volatility features of problems, something I will introduce later on in the dissertation, from Chapter 6.

Given the nature of the case study, problem transformations on the left hand side of the design tree were relatively simple, so that I was not able to consider, for instance how problem decomposition affects project structures, something I will consider later on in the dissertation.

**Problem phenomena vs complexity and volatility** In the real-world project, there was no explicit assessment of complexity or volatility, yet they existed and led to issues in the projects. Specifically, social and knowledge complexity resulted in goal conflicts, and technical and knowledge complexity to underestimating the impact of the chosen solution on existing systems, highlighting how different organisational problems tangled and led to an implemented software solution to be rejected, with consequent extra development effort. Therefore, as part of the retrospective case study, I analysed each organisational problem so as to identify its complexity or volatility characteristics and their related risk, to see the extent POE artefacts could be applied for this purpose.

I used problem diagrams to perform such an analysis at phenomena level, which made evident where complexity and problem tangling took place, hence risks were coming from. This is the case in P2, where, through context and solution interpretation, I identified all shared phenomena between organisational domains, which were the source of both technical complexity (in terms of technical phenomena to be introduced, changed or eliminated to satisfy the need) and social complexity (due to conflicting needs of stakeholders impacted by the designed solution).

In the project, these risks were only identified very late. If such an analysis had been conducted during the starting phase of the project, instead of the late execution phase,
the candidate solution would have probably been discarded or amended prior to implementa-
tion. In the dissertation, I will therefore evaluate the extent this type of analysis can help uncover technical and social complexity early on, hence reducing the risk of wasting development resources.

It is important to remark that this case study was an initial proof of concept, and concerned a relatively simple project, exhibiting primarily complexity characteristics. Later on, in Chapter 7, I will discuss a more comprehensive evaluative case study.

4.4 Summary

In this chapter, I was able to provide an interpretation of project management as complex problem solving (Ahern, Leavy, and Byrne, 2014) through the lens of POE, an existing framework for tackling complex real-world problems.

In section 4.2, I started by describing how POE concepts and artefacts could be applied to PM, which included interpreting project phases as POE problems and modelling project life cycles using the PPP. I also suggested how problem characteristics of complexity and volatility can be related to POE problem phenomena and their relationships.

In section 4.3, I tested my proposed interpretation by applying it to a retrospective case study based on a real-world project. I demonstrated how it could be used to capture key elements of the project and how it progressed step by step, with the augmented POE design tree I introduced providing a useful representation of the relation between organisational problems and project life cycle phases.

Although the case study work has limitations due to the relative simplicity of the project, the work in this chapter has nevertheless provided the foundation for further work in dissertation, starting to address the research question:

- Q1: How can PM concepts be interpreted in POE?

I have some preliminary evidence that my POE interpretation of projects and PM can provide the basis for a systematic parametrisation of projects and PM processes in the face of complexity and volatility, with the objective to mitigate the risks arising from them.

In what follows, I will build on such foundation.
Chapter 5

Factors affecting practitioners’ choices of PM approaches

This chapter considers factors which affect current choices of PM approaches made by practitioners in organisations, addressing research question

Q2: which factors affect current choices of PM approaches made by practitioners in organisations?

As discussed in Chapter 2, limited research exists on this topic, and what I have found relates primarily to IT projects and Agile methodologies. Therefore the main research objectives of this chapter are to:

• identify factors which affect practitioners’ choices and to the extent they relate to complexity and volatility, and

• gain insight into how practitioners organise their projects in response to such factors.

Moreover, in order to inform further research, I also investigate any difficulty practitioners may have in doing so, current tools which may be available to them and where the gaps are.

Our literature review in Chapter 2 provides the theoretical basis for this primary research, particularly the complexity and volatility factors considered in Section 2.2.3 and other key factors related to particular PM methodologies discussed in Section 2.4.4.
The research consists of a practitioner survey followed by in-depth semi-structured interviews. I report on each of them in Sections 5.1 and 5.2, bringing findings together in Section 5.3 and concluding the chapter in Section 5.4.

5.1 Practitioner Survey

5.1.1 Methodology

A standard survey design methodology was followed (Oates, 2005; Fowler Jr., 2013). Data were collected via an online questionnaire aimed at project, program or portfolio managers from various industries, who had worked on complex projects over at least the past three years. As already discussed in Chapter 3, several channels were used to reach potential participants, including professional networks and LinkedIn. The participation in the survey was entirely voluntary and anonymous, with the exception of those participants who volunteered for the follow-up interviews. The Open University ethical guidelines were applied throughout.

Available online technology was used to publish the questionnaire and collect participants’ responses, with the data collection taking place mainly over four months in 2018, with additional respondents in May 2019 and March 2020. All responses were given a consecutive number by the data collection tool (from 1 to 36). Tests run (5 in total) were identified as such by writing ‘test’ in the field ‘email address’ in the survey form, and eliminated from the data processing. However, I retained the original numbering of the participants for continuity. The survey responses were subsequently downloaded and a manual analysis of the results performed.

The questionnaire comprised 13 questions arranged in three sections. The questionnaire is reproduced in Appendix B.2. In order to ensure consistent data collection, questions were carefully designed and delivered in English, to avoid ambiguity and translation bias (Fowler Jr., 2013). The questionnaire was tested before being published in the field by three experienced project managers, whom I know personally and helped fine-tune its design. The use of the denominations ‘Traditional’ and ‘Agile’ methodologies, instead of ‘Predictive’ and ‘Adaptive’, with a short explanation of what was meant, is an example of the type of changes suggested.
A mixture of multiple choice and open questions was used, depending on the type of information to be collected. Closed questions were chosen for clearly structured topics in order to save the respondents time, improve reliability of the answers and simplify the evaluation process (Oates, 2005; Fowler Jr, 2013); open questions were used for topics where all the possible answers could not be anticipated (Fowler Jr, 2013). An ‘others’ option was made available in closed questions, with the purpose of letting participants add information which was not considered beforehand.

The areas explored were:

- Respondents’ demographics, in terms of years of work experience, current occupational role, country of work, PM methodologies they were familiar with, and type of PM certification they held. This information was collected in order to investigate possible associations between these characteristics and the choice of PM methodology in their practice.

- Characteristics of projects the respondents had worked on in the past three years, particularly in relation to complexity and volatility dimensions. This information was collected to investigate potential associations between those characteristics and the adopted PM methodologies.

- Factors influencing their methodological choices. This information was collected to assess which factors explicitly affected methodological choices in practice, in relation to what is reported in the literature.

For the latter, prompts were provided and participants were asked to select the three most influential factors with respect to each of predictive, adaptive and hybrid methodologies, with open ended choices allowing them to name additional factors.

The prompts provided were based on the complexity and volatility factors discussed in Section 2.2.3 plus two more corresponding to the level of team expertise and to mandatory requirements from the organisation’s management or PM office, as these were identified in Section 2.4.4 as key decision factors in relation to adaptive and predictive methodologies; they are also helpful in separating practices related to complexity and volatility.
of organisational problems from those due to contextual or cultural organisational influences. The full list of prompts, as included in the questionnaire, is as follows, with their code included in brackets:

- Management and/or PM office requirement (MANPMOREQ)
- Large number of stakeholder or organisational units involved (NUMSOC)
- Diversity of stakeholder (DIVSOC)
- Large number of technologies or interfaces involved (NUMTEC)
- Novelty or uniqueness of the technical solution (NOVELTEC)
- Lack of pre-given knowledge at project start (KNOWLEDGEST)
- Rate of change in the organisation (CHANGESOC)
- Rate of change in the technical solution (CHANGETEC)
- Rate of change in the external environment, such as legal regulations (CHANGEENV)
- Uncertainty of goals, unclear meanings or stakeholder’ hidden agenda (UNCERGOAL)
- Complicated communication due to organisational or technical characteristics (COMPLCOMM)
- Urgency (URGENCY)
- High level of expertise in project team (TEAMEXP)

5.1.2 Summary of findings

I received 31 completed questionnaires. Before analysis, I normalised the data (e.g., equating ‘United Kingdom’ and ‘UK’ for country of work) and classified answers related to PM methodologies in use and PM certifications held into adaptive, predictive or other.
Respondents’ demographics  The majority (over 77%) of respondents had over 5 years’ experience as project managers, worked in the European countries, particularly United Kingdom and Germany, and held PM certification in relation to specific predictive methodologies, with 19% also having certifications for adaptive methodologies. Most of them (93%) were based in large enterprises (250+ employees). A summary of the frequency tables can be seen in Figure 5.1.

<table>
<thead>
<tr>
<th>COUNTRY &amp; COMPANY SIZE</th>
<th>COMPANY SIZE</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>Large: 250+ staff</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Medium: 50 to 249 staff</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mix of all sizes</td>
<td>1</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>several countries in EU and NAFTA</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>South Africa</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>United States</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Grand Total</td>
<td>29</td>
<td>31</td>
</tr>
</tbody>
</table>

Project characteristics and applied methodologies  Participants were asked to focus on projects they had worked on in the last three years. There was a good spread of project types in the sample (see Figure 5.2 left), although information systems/software projects were the largest proportion (42%). The vast majority of projects were considered complex by the respondents (see Figure 5.2 right), with a sizeable proportion (39%) also seen as volatile. Hybrid methodologies were predominant (61%) followed by predictive ones (36%) (see Figure 5.3). The frequency table showing the methodology applied according
to project type and project characteristics is displayed in Figure 5.4. There, I can observe how hybrid methodologies are applied equally to different types of projects: to complex, and to complex and volatile projects, while predictive methodologies are mostly applied to complex projects and to the only reported volatile project. Furthermore, it was not possible to find any correlation between the methodology applied and demographics of the respondents.

**Figure 5.2:** Left: project types. Right: project characteristics.

**Figure 5.3:** Applied methodologies
### Chapter 5. Factors affecting practitioners' choices of PM approaches

#### Figure 5.4: Project type, characteristics and applied methodologies

<table>
<thead>
<tr>
<th>PROJECT CHARACTERISTICS</th>
<th>PROJECT TYPES</th>
<th>APPLIED METHODOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both complex and volatile</td>
<td>Administrative/Management</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Information Systems (Software)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Product and Service Development</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mix of project types</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Strategic Change Projects</td>
<td>1</td>
</tr>
<tr>
<td>Mostly complex</td>
<td>Administrative/Management</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Information Systems (Software)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Product and Service Development</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Mix of project types</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Strategic Change Projects</td>
<td>1</td>
</tr>
<tr>
<td>Mostly volatile</td>
<td>Administrative/Management</td>
<td>1</td>
</tr>
</tbody>
</table>

**Figure 5.4:** Project type, characteristics and applied methodologies.
Moreover, 16 respondents indicated they had applied a mix of approaches and were asked to provide a brief description of what they did. In seven cases, they described their approach as predictive with some adaptive components, citing organisational policy as the main reason for the prevalent predictive element: adaptive practices were adopted primarily for software/IT components or to address specific needs, such as fast-prototyping or encouraging self-sufficient teams. In two cases, an adaptive approach had been tried, but practices had reverted to more traditional ones. In another case, the organisation was transitioning from traditional to agile, so different teams were applying different approaches. In just three cases, the choice of methodology was seen as dependent on the scope of the project, or of elements of it, and on the stakeholders involved, and the choice made was based on the experience of the project manager. The description of the different approaches is listed in Figure 5.5.

**Factors influencing methodological choices** The factors used as prompts together with the ones added by participants in their open choices, and their associated codes and frequency are summarised in Table 5.1. An overview of their frequency in survey responses, grouped by PM methodology, is depicted in Figure 5.6.
The factors added by the respondents were either included in the list of factors and marked with ‘*’ or, if applicable, added to given prompts with the same meaning. The factor ‘Management or Project Management Office requirement’, for instance, was re-defined as ‘Management/PMO/external requirement or standard approach’, to include factors added by the respondents, such as ‘external funding’ or ‘standard approach’.

<table>
<thead>
<tr>
<th>Code</th>
<th>Response</th>
<th>Frequency Predictive</th>
<th>Frequency Adaptive</th>
<th>Frequency Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMSOC</td>
<td>Large number of stakeholder/units</td>
<td>18</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>DIVSOC</td>
<td>Stakeholder diversity</td>
<td>6</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>NUMTEC</td>
<td>Large number of technologies/interfaces</td>
<td>9</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>COMPLCOMM</td>
<td>Complicated communication</td>
<td>7</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>UNCERGOAL</td>
<td>Uncertain goals/unclear meaning/hidden agenda</td>
<td>6</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>CHANGESOC</td>
<td>Rate of change of organisation</td>
<td>4</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHANGETEC</td>
<td>Rate of change of technical solution</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>NOVELTEC</td>
<td>Novelty or uniqueness of technical solution</td>
<td>1</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>CHANGEENV</td>
<td>Rate of change of external environment</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>MANPMOREQ</td>
<td>Management/PMO/external requirement or standard approach</td>
<td>26</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>URGENCY</td>
<td>Urgency</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>KNOWLEDGEST</td>
<td>Lack of knowledge at start</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>TEAMEXP</td>
<td>Team expertise</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>*HIGHRISK</td>
<td>High risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*FIXSCOPE</td>
<td>Variability of time &amp; budget with fixed scope</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*VARSCOPE</td>
<td>Variability of scope with fixed time &amp; budget</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*FIXALL</td>
<td>Fixed scope, budget &amp; time</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.1:** Factors provided as prompts and those added by respondents (marked with ‘*’).
FIGURE 5.6: Factor frequencies by methodology (factors added by respondents marked with “*”)
Chapter 5. Factors affecting practitioners’ choices of PM approaches

For predictive methodologies (Figure 5.6, top left), management and/or PMO requirements (MANPMOREQ) are by far the most influential factor, followed by the presence of a large number of stakeholder/organisational units involved in the project (NUMSOC). The next factor is the presence of a large number of technologies involved (NUMTEC), but this is close to the following factors, i.e., the complexity of communication (COMPLCOMM) and those after that, so its influence is less pronounced.

For adaptive methodologies (Figure 5.6, top right), the two most influential factors are uncertainty of goals (UNCERGOAL) and rate of change of technical solution (CHANGE TEC). These are followed by three factors which appear equally influential: urgency (URGENCY), novelty or uniqueness of the solution (NOVELTEC) and rate of change in the environment (CHANGEENV).

Finally, for hybrid approaches (Figure 5.6, bottom), if I disregard organisational factors MANPMOREQ and TEAMEXP, the two most influential factors are the number of stakeholders involved (NUMSOC) and the rate of change in the organisation (CHANGESOC), closely followed by uncertainty of goals (UNCERGOAL), which, in turn, is closely followed by the presence of a large number of technologies involved (NUMTEC) and their propensity to change (CHANGETEC). This pattern continues in a decreasing linear fashion for the remaining factors, so the differences in frequencies between one factor and the next are small.

Of the factors added by respondents, high level of organisational risk (HIGHRISK) was mentioned as influencing predictive methods. One respondent used project scope, budget and time criteria to differentiate between choices: when the scope was fixed (i.e., all requirements must be delivered, FIXSCOPE), but time and budget were variables, then a predictive methodology was suggested as appropriate; when time and budget were fixed, but the scope was variable (VARSCOPE), such as in continuous improvement initiatives, the choice was an adaptive methodology; when there was a need to balance all three, then a mixed approach was chosen (FIXALL).

Figure 5.7 provides a mapping between factors and choices of predictive vs. adaptive. It can be observed that some factors, such as NUMTEC or CHANGETEC, are only mentioned in relation to one project methodology, others, such as MANPMOREQ or URGENCY, are mentioned in relation to both project methodologies.
Figure 5.7: Factors influencing the choice of predictive vs. adaptive methodologies: comparing frequencies (factors added by respondents marked with "*")
5.1.3 Analysis of findings

In this section I return to the findings of the survey and make an interpretation of their specific relevance to this research.

The survey results indicate a high adoption of hybrid approaches in complex projects, which is in alignment with the trend acknowledged in the literature and discussed in Chapter 2. Moreover, they indicate that the most common ways to integrate predictive and adaptive methodologies is by embedding adaptive components within predictive approaches, and that this is the case not just in software development projects, as already reported in the literature, but also more generally, although it is true that software projects were a large proportion of my sample.

The number of new factors added by respondents was minimal, confirming that the complexity and volatility factors I have identified from the literature and included as prompts in the survey are recognised by practitioners and have a bearing in their choice of PM methodology.

In my findings, organisational culture and management preferences (MANPMOREQ) remain the most influential factor in the adoption of predictive methodologies, which is consistent with previous studies (Theocharis et al., 2015; West et al., 2011) that have argued that the choice of predictive PM methodologies is still mostly based on the reluctance of management to relinquish tried and tested practices and move towards more adaptive ones, although external regulatory requirement have an influence too (West et al., 2011).

Once I disregard MANPMOREQ and TEAMEXP, the most influential factors in the choice of predictive methodologies are the number of stakeholder/units (NUMSOC) followed by the number of technologies/interfaces (NUMTEC), which relate to social and technical complexity respectively (see Section 2.2.3). In relation to the choice of adaptive methodologies, the most influential factors are uncertain goals (UNCERGOAL) and rate of change of technical solution (CHANGETEC): these factors correspond to combined social and knowledge volatility, and to technical volatility, respectively (see Section 2.2.3). Therefore, I observe that, once contextual organisational factors are taken out of the equation, the general trend of alignment of predictive methodologies with complexity and
adaptive methodologies with volatility that I discussed in Chapter 2 is also evident in my survey findings.

For hybrid methodologies, NUMSOC and CHANGESOC (related to social complexity and volatility) come first with equal influence, closely followed by UNCERGOAL (related to combined social and knowledge volatility), and then NUMTEC and CHANGE TEC together (related to technical complexity and volatility), although differences in influence among them and with respect of other factors is less pronounced than in the ‘pure’ forms.

While the survey helped me identify the factors which affect practitioners’ choices of PM methodology, and to the extent they relate to complexity and volatility findings in the literature, it falls short from providing insights into how practitioners organise their projects in response, other than for a generic indication that hybrid approaches tend to embed adaptive elements within otherwise predictive methodologies. This was therefore investigated further in the follow-up interviews, which I consider next.

5.2 Practitioner interviews

Semi-structured interviews were conducted to investigate why the identified factors from the survey affect practitioners’ choices of PM methodology and how practitioners organise their projects in response. The interviews also provided an insight into methodological tools currently used by practitioners in setting up their projects and where gaps exist.

5.2.1 Methodology

A total of 10 survey participants volunteered to be interviewed. The interviews were conducted in person or on the phone, at the participant’s preference, and had a duration between 25 and 40 minutes. They were not recorded, but detailed notes were taken for follow-up analysis. Data collection took place from May to June, 2019.

The interview script was based on the outcome of the survey, and pre-tested with one project manager to improve its design. As a result of this test, it was decided to send interviewees their responses to the survey in advance to make it easier for them to refer to their previous answers during the interview. Interviewees were additionally
sent a leaflet explaining the objective of the research and other information related to the interview protocol, anonymity and data protection.

After the interviews, data analysis followed the steps for qualitative data analysis described in Yin (2015): after compiling the responses in a single spreadsheet, the answers to each question were split into single concepts or key ideas and then grouped following emerging themes for each of the objectives of the interview, so as to enable data interpretation and the drawing of conclusions.

The interview was structured in four parts.

The first part had the objective to deepen and validate survey answers and explore the rationale for their choice of factors which influence the use of predictive, adaptive or hybrid PM methodologies.

The second part had the objective to validate my definitions of complexity and volatility, and participants were asked to relate them to their own practice by providing examples of projects exhibiting such characteristics.

The third part had the objective to explore how the respondents organise their projects in relation to characteristics of volatility and complexity.

The forth part was related to the approach taken to parametrise projects, the tools available to them and which further support would be desirable.

Finally, the respondents were invited to add any comment they may have and given the opportunity to receive a copy of the results of the research.

5.2.2 Summary of findings

Interviewees’ characteristics As a first step, demographic data, project characteristics, PM methodologies applied, and selected factors in relation to adaptive, predictive and hybrid methods provided by the interviewees during the survey were compared to the complete results of the survey. As displayed in Figures 5.8 and 5.9, there are no remarkable differences either in relation to demographic data or in relation to project characteristics and methodologies applied.

Similarly, it is not possible to observe remarkable deviations with regard to the factors mentioned in relation to adaptive predictive and hybrid methods already displayed in
Figure 5.8: Summary of respondents demographics, comparing interviewed vs not interviewed respondents


Figure 5.9: Project type, characteristics and applied methodologies, comparing interviewed vs not interviewed respondents

Figure 5.6. The comparison between the responses obtained from interviewed and not interviewed respondents is shown in Figure 5.10.

Rationale for selecting factors in relation to PM methodologies  The first part of the interview had the objective to deepen and validate the survey answers in relation to factors which influence the choice of predictive, adaptive or mixed PM methodologies. The obtained results, on the one hand, validated the answers to the survey, as I could not find any evidence of misinterpretation (no additional explanation in regard to the meaning of the factors was required), and on the other hand, they allowed me to understand the rationale behind the selection of the factors. Additionally they gave a first indication of how the practitioners use the different PM methodologies as a control of risks arising from complexity and volatility.

In the presence of complexity, specially in case of large number of stakeholder or complicated communication, predictive methods were seen as providing tools to ensure a clear assignment of responsibilities and effective stakeholder management, as mentioned by respondent 16:

Successful communication and engagement is the key, keep it simple but
Figure 5.10: Factor frequencies by methodology, interviewed vs not interviewed respondents (factors added by respondents marked with ***)
overall with a huge number with different units there will be interfaces and interdependence and everybody can understand and plan

and confirmed by respondent 22:

The traditional way of managing stakeholder, taking the time to work on stakeholders analysis and how to address issues that pays dividends.

Furthermore, other participants, such as respondents 3, 14, 16, 22, 30, 31 and 34, mentioned that adaptive methodologies cannot handle large teams; respondent 3, for instance, stated that:

in case of large number of stakeholders, typical agile characteristics are not feasible, stand up meeting or different time zones.

The ability to deal with risk and change control, were also mentioned in relation to predictive PM methodologies, as stated by respondent 32:

traditional methods are easier and more transparent in case of changes because it offers a tool set to deal with it

and confirmed by respondent 30. Likewise, adaptive methods cannot deal with changing teams, as close collaboration is a requirement for agility as also stated by respondent 32.

As expected, management requirement, team expertise and availability of tools played also an important role in the decision to use predictive PM methodologies. The advantage of using an established method is described by respondent 8:

People know how to work in a traditional environment, the focus is on the project and not in how to run it.

Similarly, respondents 32 and 14 refer to the organisations as not ready for agile, while respondents 22, 27, 30, 31 and 34 pointed out that the use of predictive tools is a requirement from the PM Office.

Changing environments and technical solutions make planning difficult and thus require adaptive solutions where short term forecasts and smaller tasks can be easier synchronised, as mentioned by respondents 8, 14 and 27. The same applies to goals uncertainty, unclear requirements and the need to learn, as mentioned by respondent 27:
Chapter 5. Factors affecting practitioners’ choices of PM approaches

if you know that things are changing or that you need to learn along then it is better to release small things and incorporate in your next iteration(...) embrace the risk from the beginning and you need to evaluate continuously if it is what your business needs

and supported by respondent 32 and respondent 14.

Adaptive solutions also contribute in the handling of urgency, as described by respondent 32, who states that they:

deliver the most important and urgent value first.

Predictive methodologies were seen as providing a good toolset to structure and plan the project and manage stakeholder, but not having the capability to react quickly to change (respondent 32), so that hybrid methodologies were seen by many respondents as providing the best of both worlds to help deliver a successful project (respondents 3, 14 and 27). As a consequence, while management and PMO Office tend to require planning, technical teams can work in an adaptive manner, adopting some agile practices, such as stand-up meetings, and be empowered to execute their tasks (respondents 8, 14 and 22), provided they have the right mindset (respondent 3).

Though, in the end, as pointed out by respondent 30,

if you have a good team, it does not matter which methodology you use

and, as mentioned by respondent 22:

People in team with insight mitigates the volatility (...) project managers with skills help the decision to do right thing.

Notion of complexity and volatility The second part of the interview was focused on validating the notions of complexity and volatility from the literature. These notions were confirmed by all respondents, who gave some examples based on real-life situations and made some additional remarks.

Some noted that there is a sort of notion of ‘self made complexity’ and that ‘changes can be a source of complexity’. Respondent 14, for instance, exemplified how the desire of the organisation to benefit from new technologies makes the product development process more complex when trying to adapt existing products to new features. Respondents
8, 34 and 30 mentioned specifically changes in the organisation in complex environments as an additional source of complexity. However, changing organisations were also mentioned in relation to volatility (respondents 27, 30), as well as changing timelines and deadlines (respondents 3, 31).

**Project architecture in the presence of complexity and volatility** In the third part of the interview, respondents were asked to describe how they parametrise complex projects, volatile projects and complex and volatile projects in order to create a matching project architecture.

The answers obtained gave a good indication of how practitioners attempt to mitigate the risks arising from complexity and volatility and allowed to identify the way in which they attempt to mitigate these risks.

Up-front planning, for instance, mostly associated with strict change control, was identified by the respondents as a measure to deal with both complex and complex and volatile projects, also in combination with agile execution as stated by respondents 3, 14, 27 and 32. Strict change control as a way of minimising changes, on the other hand, was specifically related to volatility by respondent 34.

Respondent 8, for instance, mentioned incremental deliveries and prototyping in relation to both complexity and volatility, as a way of reducing complexity “using pilots as blueprint for projects” and volatility, when “focusing on the short term.”

Simplifying scope, either by eliminating sources of complexity (respondent 8) or using known technologies (respondent 30), was recognised as a control for complex and volatile projects.

Decomposing scope into work packages with minimal inter-dependency (respondent 8), were associated to complex projects and, in combination with stringent governance and accountability, also to volatile and complex and volatile projects (respondents 16, 31, 32, 34).

Front-loading the project with knowledge discovery and quality gates as a precondition for each phase, was also mentioned as a way of dealing with complex projects.

Planned communication, ensuring one source of truth and explicit documentation, were also identified as controls for complexity (respondents 3, 27, 30), while “lots of
communication’ (respondent 30), was also mentioned in relation to volatile projects.

Short and frequent learning cycles, as stated by respondent 27

identify early on areas for reviews which need more interactivity/adaptability

short and frequent development and feedback cycles, either as a source of continuous
adaption, as mentioned by respondent 3

constant evaluation of requirements and internal alignment during implementa-
tion

or just short incremental iterations, were identified by respondents 8, 27 and 32 as controls for volatile, complex and volatile projects and complex projects.

Stakeholder involvement in the definition of priorities and so deal with urgency in both complex and volatile projects, was cited by respondents 27 and 31.

Furthermore, respondents 14 and 30 identified verbal communication as control of complexity and volatility.

Team expertise was mentioned explicitly as a control for complexity (respondent 22), while similarly, resource allocation according to the type of complexity was acknowledged by several respondents as a way to deal with complex and volatile projects (respondents 3, 14 and 22).

Figure 5.11 provides a summary of the controls mentioned by the respondents in relation to complex, complex & volatile and volatile projects.

Methodological tools and gaps The forth part of the interview provided input in relation to project parametrisation. I could identify the methodological tools in use and the areas where more methodological support would be desirable for the practitioners (gaps).

Many interviewees (respondents 14, 16, 27, 31, and 34) noted how they relied heavily on their experience and tried and tested practices, which they would adapt from project to project, and align with organisational culture. Spending lots of time upfront understanding the problem and the organisation in order to parametrisate each project was deemed very important by relatively few (respondents 31 and 34), as well as talking to experts to validate their initial project architecture (respondent 31).
<table>
<thead>
<tr>
<th>ID</th>
<th>Control - as mentioned by respondents</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>allocate resources differently depending on the type of complexity</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>constant evaluation of requirements and internal alignment during implementation</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>project start needs to be very detailed</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>sharing one source of truth</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>traditional planning, deliver according to urgency, very strict change control</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>8</td>
<td>find where complexity can be eliminated</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>if working across time zones, reduce complexity by having regional teams that work individually, and</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>coordinate incremental delivery: focus on short term</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>need to break down the project and eliminate dependencies</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>piloting: using pilots as blueprint for project</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>small teams facilitate common understanding in short iterative cycles</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>14</td>
<td>mixture between traditional for the planning and then agile for the execution (stand ups, flat hierarchy)</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>to have a different team expertise according to the problem you want to solve or integrate the suppliers</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>16</td>
<td>clearly defined roles and responsibilities and stringent governance and accountability in place</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>22</td>
<td>people in senior position to have the right emotional intelligence to deal with it</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>resilience support</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>right people; experienced team</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>27</td>
<td>deal with the now, but keep looking ahead</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>document very carefully</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>identify early on areas for reviews which need more interactivity/adaptability</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>traditional framework at the first phase to find requirement, agility for the execution</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>30</td>
<td>communicate quickly and effectively</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>communication</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>try to simplify by using tried and tested solution (e.g. known technology)</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>31</td>
<td>separate what can be done early and late</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>use plan driven all through</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>32</td>
<td>divide and conquer; cut in pieces with clear responsibility and communication structure</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>Scaling scrum, scaling agile approaches</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>short iterations; reconsider requirements more often</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td>34</td>
<td>careful find out preconditions to start all phases</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>inform stakeholder who influence and define success measures to reconsider solutions that minimise changes</td>
<td>Complex &amp; Volatile</td>
</tr>
<tr>
<td></td>
<td>use plan driven all through</td>
<td>Complex &amp; Volatile</td>
</tr>
</tbody>
</table>

**Figure 5.11:** Controls applied to deal with complex, complex & volatile and volatile projects
Some used or adapted templates provided by their PMO or developed in previous projects (respondent 30 and 34). Some common predictive tools were considered effective by many, in particular, the traditional way of analysing and managing stakeholder (respondents 22 and 32) and developing communication plans (respondent 16) to deal with social complexity, and traditional risk management and control approaches, such as risk maps and quality gates (respondents 3, 22 and 34). For the estimation of technical complexity, function points (respondent 3) and complexity points (respondent 8) were mentioned.

Despite the many PM tools available, gaps were perceived by all but one participant, who would welcome more methodological support at the very start of a project. In particular, there was a feeling that support for the whole front-end is lacking (respondent 30) and that often practitioners are faced with a “black box” (respondent 3) at the start. The “holy grail” (respondent 27) would be an approach allowing practitioners to gather the information at the start needed to make a sound judgement on how to set up their project, mainly with the purpose to identify effort and help to break down projects in manageable tasks and in this way allow to assign the right skill sets and focus on areas with higher risks.

5.2.3 Analysis of findings

In this section I return to the findings of the interview and make an interpretation of their specific relevance to this research.

The results of the interviews helped me validate the answers to the survey and explore the rationale behind the selection of the factors influencing choices of PM methodologies.

In line with both literature and survey, management preference and team knowledge, together with a better handling of large numbers of stakeholder or technologies, motivated the use of predictive methods, while volatility and knowledge complexity motive the use of adaptive ones, with hybrid approaches seen as combining the advantages of both.

Interestingly, an influencing factor in the choice of predictive methodologies was their ability to control change, as opposed to the tendency of adaptive methodologies
to embrace change. The rate of change in the organisation or project team, for instance, was perceived as something in need of control, hence better handled by traditional approaches, while other dimensions of volatility, such as changing in the external environment were deemed as requiring an adaptive approach. This can be explained in terms of controllability or the degree of influence the project team has on the risk (Fan, Lin, and Sheu, 2008). While internal factors may be controlled either by the team or key stakeholder, external factors require the project to adapt in order to reduce the risk.

Our definitions of complexity and volatility were recognised by all respondents, who could relate them to aspects of their own projects.

When coming to the set up of projects in the presence of complexity, volatility or both, I could observe how participants associated certain measures or control. It is remarkable that some controls were mentioned in relation to both complex and volatile projects, giving an indication that the personal preferences of the project managers also play a role when selecting a PM methodology.

In order to understand the nature of those controls and identify patterns, I made an interpretation of the responses which enabled me to standardise and group the controls based on their meaning.

In relation to the classification of the controls, which happened post-interviews, it is important to remark that the participants were not given any guidance, as the focus was their understanding of the nature of the controls and how they mitigate risk.

I could observe that some of the measures mentioned by the respondents consisted of a sum of different controls, which even could be related to different PM methodologies. The measure “traditional planning, deliver according to urgency, very strict change control”, as mentioned by respondent 3, for instance, includes three different controls: up-front plans (predictive), stakeholder required to identify and agree high priorities first (adaptive) and strict change control (predictive). Accordingly, this measure was associated to the three mentioned standard controls. Similar behaviour could be observed in other responses, such as “Scaling scrum, scaling agile approaches”, as mentioned by respondent 32, which was handled in a similar fashion, relating this measure to up-front plans, for the “scaling” part and to short and frequent development and feedback cycles for the “agile” part.
Communication plan, decomposition into work packages with minimal interdependency, establishing one source of truth, explicit documentation, formal quality gates, front-loading the project with knowledge discovery, stakeholder management, strict change control, stringent governance and accountability and up-front plans, were defined as controls related to predictive methods.

The control ‘prototyping’, which was raised by one of the respondents with the meaning of using pilots as blueprint for projects, was classified by me as predictive due to the fact that the increments are usually planned up-front, in contrast to incremental delivery, where scope develops over time.

Scope simplification, stakeholders required to identify and agree high priorities first, short and frequent development and feedback cycles, short and frequent learning cycles, team expertise and verbal communication were the controls related to adaptive methods. Measures mentioned by the participants in relation to incremental delivery or constant evaluation of requirements and alignment were consolidated as ‘short and frequent development and feedback cycles’, due to the similar nature of the control.

A list of the standardised controls associated to predictive methodologies and their relation to the answers given by the respondents are shown in Figure 5.12, while the standardised controls associated to adaptive methodologies and their relation to the answers given by the respondents are displayed in Figure 5.13.

In accordance with what was observed in the first part of the interview in relation to the factors affecting the choice of methodologies, I was able to observe that some standardised controls associated to predictive PM methodologies were not only associated to complexity but to volatility as well. The relationship between the factors and controls is explored in Section 5.3.

In Figure 5.14, I see a summary of the standardised controls grouped according to their associated PM methodology and the type of projects they are applied to.

When setting up the project architecture, respondents rely mostly on their experience and use existing tools basically to plan and follow up the project and to manage stakeholders and communication. However, there is a methodological gap in relation to the definition of the initial project architecture, something in which guidance and experience can come together, and the support of knowledge discovery at project start. Of particular
### Chapter 5. Factors affecting practitioners’ choices of PM approaches

<table>
<thead>
<tr>
<th>Standardised adaptive control type</th>
<th>Control – as mentioned by respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>scope simplification</td>
<td>find where complexity can be eliminated</td>
</tr>
<tr>
<td></td>
<td>try to simplify by using tried and tested solutions (e.g. known technology)</td>
</tr>
<tr>
<td>short and frequent development and feedback cycles</td>
<td>constant evaluation of requirements and internal alignment during implementation</td>
</tr>
<tr>
<td></td>
<td>identify early on areas for reviews which need more interactivity/adaptability</td>
</tr>
<tr>
<td></td>
<td>incremental delivery; focus on short term</td>
</tr>
<tr>
<td></td>
<td>Scaling scrum; scaling agile approaches</td>
</tr>
<tr>
<td></td>
<td>short iterations; reconsider requirements more often</td>
</tr>
<tr>
<td></td>
<td>traditional framework at the first phase to find requirement, agility for the execution</td>
</tr>
<tr>
<td>short and frequent learning cycles</td>
<td>deal with the now, but keep looking ahead</td>
</tr>
<tr>
<td></td>
<td>small teams facilitate common understanding in short iterative cycles</td>
</tr>
<tr>
<td>stakeholder required to identify and agree high priorities first</td>
<td>separate what can be done early and late</td>
</tr>
<tr>
<td></td>
<td>traditional planning, deliver according to urgency, very strict change control</td>
</tr>
<tr>
<td>team expertise</td>
<td>allocate resources differently depending on the type of complexity</td>
</tr>
<tr>
<td></td>
<td>right people; experienced team</td>
</tr>
<tr>
<td></td>
<td>to have a different team expertise according to the problem you want to solve or integrate the suppliers</td>
</tr>
<tr>
<td>verbal communication</td>
<td>communicate quickly and effectively</td>
</tr>
<tr>
<td></td>
<td>mixture between traditional for the planning and then agile for the execution (stand ups, flat hierarchy)</td>
</tr>
</tbody>
</table>

**Figure 5.12:** Standardised controls associated to predictive methodologies

<table>
<thead>
<tr>
<th>Standardised predictive control type</th>
<th>Control – as mentioned by respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>communication plan</td>
<td>communication</td>
</tr>
<tr>
<td>decomposition into work packages with minimal inter-dependency</td>
<td>clearly defined roles and responsibilities and stringent governance and accountability in place</td>
</tr>
<tr>
<td></td>
<td>divide and conquer; cut in pieces with clear responsibility and communication structure</td>
</tr>
<tr>
<td></td>
<td>if working across time zones, reduce complexity by having regional teams that work individually</td>
</tr>
<tr>
<td></td>
<td>need to break down the project and eliminate dependencies</td>
</tr>
<tr>
<td>establishing one source of truth</td>
<td>sharing one source of truth</td>
</tr>
<tr>
<td>explicit documentation</td>
<td>document very carefully</td>
</tr>
<tr>
<td>formal quality gates</td>
<td>careful find out preconditions to start all phases</td>
</tr>
<tr>
<td>front-loading the project with knowledge discovery</td>
<td>careful find out preconditions to start all phases</td>
</tr>
<tr>
<td></td>
<td>identify early on areas for reviews which need more interactivity/ adaptability</td>
</tr>
<tr>
<td>prototyping</td>
<td>planning; using pilots as blueprint for project</td>
</tr>
<tr>
<td>stakeholder management</td>
<td>inform stakeholder who influence and define success measures to reconsider solutions that mirror</td>
</tr>
<tr>
<td>strict change control</td>
<td>inform stakeholder who influence and define success measures to reconsider solutions that mirror</td>
</tr>
<tr>
<td></td>
<td>traditional framework at the first phase to find requirement, agility for the execution</td>
</tr>
<tr>
<td></td>
<td>traditional planning, deliver according to urgency, very strict change control</td>
</tr>
<tr>
<td></td>
<td>use plan driven all through</td>
</tr>
<tr>
<td>stringent governance and accountability</td>
<td>clearly defined roles and responsibilities and stringent governance and accountability in place</td>
</tr>
<tr>
<td></td>
<td>divide and conquer; cut in pieces with clear responsibility and communication structure</td>
</tr>
<tr>
<td>up-front plans</td>
<td>mixture between traditional for the planning and then agile for the execution (stand ups, flat hierarchy)</td>
</tr>
<tr>
<td></td>
<td>project start needs to be very detailed</td>
</tr>
<tr>
<td></td>
<td>Scaling scrum; scaling agile approaches</td>
</tr>
<tr>
<td></td>
<td>traditional framework at the first phase to find requirement, agility for the execution</td>
</tr>
<tr>
<td></td>
<td>traditional planning, deliver according to urgency, very strict change control</td>
</tr>
<tr>
<td></td>
<td>use plan driven all through</td>
</tr>
</tbody>
</table>

**Figure 5.13:** Standardised controls associated to adaptive methodologies
### Figure 5.14: Controls associated to complex, volatile and complex & volatile projects, grouped by type of project

<table>
<thead>
<tr>
<th>Standardised control type</th>
<th>Project</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>communication plan</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td>decomposition into work packages with minimal inter-dependency</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>establishing one source of truth</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td>explicit documentation</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td>formal quality gates</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td>front-loading the project with knowledge discovery</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>incremental delivery</td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>prototyping</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td>strict change control</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>stringent governance and accountability</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>up-front plans</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td>verbal communication</td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>scope simplification</td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td>short and frequent development and feedback cycles</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>short and frequent learning cycles</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>team expertise</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
<tr>
<td>stakeholder management</td>
<td>Volatile</td>
<td></td>
</tr>
<tr>
<td>stakeholder required to identify and agree high priorities first</td>
<td>Complex &amp; Volatile</td>
<td></td>
</tr>
</tbody>
</table>
interest would be the ability to address the following problems:

- how to break down work packages effectively and eliminate peaks by fine-tuning iterations,
- how to estimate the effort needed to manage communication and alignment with stakeholder,
- how to decide when being agile is an option or a must.

5.3 Discussion

In order to compare the factors mentioned by the respondents in the survey and analyse their relationship to the concepts of complexity and volatility in their dimensions: social, technical and knowledge as described in Chapter 2, I extended Table 2.7 where I had previously related the factors identified as source of complexity and volatility, the way they manifest and their related risk, with the controls proposed by the practitioners. The result is displayed on Tables 5.2 and 5.3 where I combine the information from the literature with the primary research.

As discussed in Sections 5.1.3 and 5.2.3, hybrid approaches were seen as combining the advantages of both predictive and adaptive approaches, hence the factors mentioned as influencing the use of hybrid methodologies were the sum of the factors motivating both the use of predictive and adaptive approaches, which is consistent with the hybrid method introduced in Chapter 6.

By synthesising all findings, I was able to generate an initial mapping between volatility and complexity dimensions and PM controls, which I see next.

Social complexity  NUMSOC, DIVSOC are sources of social complexity and manifest in the increase of interactions and complicated communication. Predictive controls, such as: establishing a communication plan or one source or truth, having explicit documentation or formal quality gates, stringent governance and accountability and stakeholder management, help to overcome coordination and communication challenges and thus prevent overrun of time and budget. Adaptive controls, such as to involve key stakeholder in short and frequent development and feedback cycles, are a way to ensure that
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Factor</th>
<th>Manifests</th>
<th>Predictive control</th>
<th>Adaptive control</th>
</tr>
</thead>
</table>
| Social Complexity | NUMSOC    | Increase of interactions and complicated communication                     | Communication plan  
Establishing one source of truth  
Explicit documentation  
Formal quality gates  
Stakeholder management  
Stringent governance and accountability | n/a                                                 |
| Social Complexity | DIVSOC    | Increase of interactions and complicated communication                     | Communication plan  
Establishing one source of truth  
Explicit documentation  
Prototyping  
Formal quality gates  
Stakeholder management  
Stringent governance and accountability | short and frequent development and feedback cycles |
| Technical Complexity | NUMTEC   | Affect ability to predict behaviour  
Increases the difficulty to estimate effort | Decomposition into work packages with minimal inter-dependency  
Establishing one source of truth  
Explicit documentation  
Formal quality gates  
Strict change control  
Stringent governance and accountability  
Up-front plans | Team expertise  
Scope simplification  
short and frequent development and feedback cycles |
| Knowledge Complexity | KNOWLEDGEST | Information fragmentation  
Stakeholder holding different understanding of the problem  
Multiple objectives  
Unclear goals and objectives | Formal quality gates  
Front-loading the project with knowledge discovery  
Prototyping | short and frequent development and feedback cycles  
Short and frequent learning cycles |
| Social & Technical Complexity | COMPLCOMM | Increase of interactions and complicated communication | Communication plan  
Establishing one source of truth  
Explicit documentation  
Stringent governance and accountability  
Up-front plans |                                                   |
| Social & Knowledge Complexity | UNCERGOAL | Information fragmentation  
Multiple objectives | Communication plan  
Establishing one source of truth  
Formal quality gates  
Prototyping  
Stakeholder management  
Strict change control  
Stringent governance and accountability | Short and frequent development and feedback cycles |

**TABLE 5.2: Manifestation of complexity and associated risks controls**
### Table 5.3: Manifestation of volatility and associated risk controls

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Factor</th>
<th>Manifests</th>
<th>Predictive control</th>
<th>Adaptive control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Volatility</td>
<td>CHANGE-SOC</td>
<td>Shifting requirements, Non-aligned goals with key stakeholder</td>
<td>Explicit documentation, Strict changes control</td>
<td>Short and frequent development and feedback cycles</td>
</tr>
<tr>
<td>Technical Volatility</td>
<td>CHANGE-TEC</td>
<td>Produces new technical solutions and drop others into oblivion</td>
<td>Strict change control</td>
<td>Team expertise, Short and frequent development and feedback cycles</td>
</tr>
<tr>
<td>Technical Volatility</td>
<td>NOVELTEC</td>
<td>Produces new technical solutions and drop others into oblivion</td>
<td>Prototyping</td>
<td>Team expertise, Short and frequent learning cycles, Verbal communication</td>
</tr>
<tr>
<td>Knowledge Volatility</td>
<td>CHANGE-ENV</td>
<td>Elements of the project are difficult to control, Non-aligned goals with the environment</td>
<td>Prototyping, Strict change control</td>
<td>Scope simplification, Short and frequent development and feedback cycles, Short and frequent learning cycles, Stakeholder required to identify and agree high priorities first</td>
</tr>
<tr>
<td>Social, Technical &amp; Knowledge Volatility</td>
<td>URGENCY</td>
<td>Increases the need of coordination and the interdependence between the project components</td>
<td>Prototyping, Strict change control</td>
<td>Scope simplification, Short and frequent development and feedback cycles, Stakeholder required to identify and agree high priorities first, Verbal communication</td>
</tr>
</tbody>
</table>
relevant stakeholder, specially when diverse, understand and agree on the solution that is being delivered by the project.

Technical complexity  NUMTEC is a source of technical complexity. It affects the ability to predict behaviour and increases the difficulty to estimate effort. Most of the predictive controls are set up to reduce the effects of the technical complexity. Basically the strategy is to divide and conquer, by decomposing scope into work packages with minimal inter-dependency. This decomposition will require coordination, which is achieved by planning up-front, ensure understanding between the teams establishing one source of truth and having explicit documentation. Stringent governance and accountability, and strict change control are used to avoid scope creep, while formal quality gates ensure that risk is not carried forward from one phase to the other.

When coming to the adaptive controls, scope simplification helps to reduce technical complexity, while an expert team has more chances to cope up with it. In the presence of a changing environment or a new technology short and frequent development and feedback cycles, where the scope is contained in each cycle, are a way to reduce the risk of development a wrong or obsolete solution.

Knowledge complexity  KNOWLEDGEST was identified as source of knowledge complexity, it may manifest in information fragmentation, stakeholder holding different understanding of the problem, multiples objectives or unclear goals and objectives. Although it is related to the process of knowledge discovery, knowledge complexity also derives from the complexity of the related socio-technical components. I postulate that, the controls applied to the risks arising from knowledge complexity will depend on the source of the risk, while factors related to knowledge discovery will require adaptive methodologies, factors related to complicated interrelations will require controlled processes given by predictive PM methodologies. Formal quality gates, as already mentioned, will ensure that risk is not carried forward from one phase to the next, while prototyping will be used to promote learning of technical components while ensuring that this learning is shared by the stakeholder in a similar way that front-loading the project with knowledge discovery will do.
Adaptive controls such as short and frequent learning cycles and short incremental iterations will ensure continuous learning through the project and make adjustments from one cycle to the next, which would be especially useful in the presence of volatility.

**Several dimensions of complexity combined**  COMPLCOMM is a source of social and technical complexity, it manifests as increase of interactions and complicated communication. As in social complexity, predictive controls, such as establishing a communication plan or one source or truth or having explicit documentation, or stringent governance and accountability, help to coordinate the communication between the different stakeholder and thus prevent overrun of time and budget. Up-front planning, on the other hand, will help to coordinate communication, especially in the presence of technical complexity.

UNCERGOAL is a source of social and knowledge complexity. It manifests in information fragmentation and multiple objectives that may lead to stakeholder attempting to sabotage the project. Predictive controls such as communication plan, strict change control, establishing one source of truth, formal quality gates, stringent governance and accountability, and stakeholder management ensure stakeholder involvement and risk transfer. Adaptive controls, such as short and frequent development and feedback cycles ensure, especially in volatile environments, that requirements and priorities are defined and agreed by the relevant stakeholder in short feedback cycles, which a contained scope.

**Social volatility**  CHANGESOC is a source of social volatility. It manifests through shifting requirements that may require additional effort and reworking and non aligned goals with key stakeholder that may lead to complete project failure. As I could see in the survey results, although the literature associates volatility with adaptive methodologies, respondents related CHANGESOC to predictive PM methodologies. Changing stakeholder may require strict changes control and explicit documentation to ensure knowledge transfer and thus reduce probability of incurring risk.

On the other side, short and frequent development and feedback cycles help to reduce the effects of the changes, as the risk of failure will be reduced to the amount of resources spent during the iteration, thus, the shorter the iterations, the lower the risks.
Technical volatility  
CHANGETEC and NOVELTEC are sources of risks related to technical volatility that may lead to developing new technical solutions and dropping others into oblivion. Basically, risk is reduced by short and frequent development and feedback cycles and short and frequent learning cycles, which help to reduce the effects of the changes as the effort is contained in each cycle.

Scope simplification, team expertise and verbal communication, will also contribute by speeding up communication and development.

In combination with complex environments, predictive controls which should contribute in reducing risk by strict change control and prototyping, which would be specially useful in the case of dealing with new technologies.

Knowledge volatility  
CHANGEENV is a source of knowledge complexity which manifests in elements of the projects which are difficult to control or non-aligned goals with the environment, which may lead either to disorder or to complete project failure. As in the case of knowledge complexity, knowledge volatility derives from the volatility of the related socio-technical components. Strict change control and prototyping are the predictive applicable controls, that would help to avoid disorder. Scope simplification, short and frequent learning cycles and short and frequent development and feedback cycles will help to reduce risk in case of non-aligned goals with the environment, because, as in other dimensions of volatility, the risk of failure will be reduced to the amount of resources spent during the iteration. Stakeholders required to identify and agree high priorities first, will contribute in keeping priorities aligned.

Combination of social, technical and knowledge volatility  
URGENCY is a manifestation of any combination of social, technical and knowledge complexity. It manifests in an increase of the need of coordination and interdependence between the project components which have the effect that small problems or uncertainty cause unexpectedly large effects that may lead to overspend. Prototyping and strict change control, together with scope simplification and verbal communication are applied to gain speed, specially in the presence of complexity. Short and frequent development and feedback cycles, as already
mentioned, reduce risk by limiting it to the amount of resources spent during the iterations. Goals alignment will be ensured by requiring stakeholder to identify and agree high priorities first.

An overview of the mapping between volatility and complexity dimensions and PM controls is displayed in Figure 5.15.
5.4 Summary

The objective of this chapter was to investigate which factors affect current choices of PM approaches made by practitioners in organisations.

In all, it should be mentioned that, although the results are consistent, the sample of the survey is not big enough or diverse enough to be conclusive in terms how practitioners choose and adapt project methodology for use in their organisations. But, in combination with the literature, it provided the information necessary to answer the research question

**Q2: which factors affect current choices of PM approaches made by practitioners in organisations?**

As described in section 5.1.2 I could also observe that, although the notion of complexity and volatility are known and understood by the participants, they may not always adapt the methodology completely based on the complexity or volatility they encounter, but are affected by their own beliefs and the organisational context. Project managers show a clear preference towards hybrid project architectures, mostly predictive frameworks with adaptive elements, specifically when dealing with complex, volatile, and complex and volatile projects.

I could investigate how practitioners look at complexity and volatility factors to parametrise their PM processes, which often results in ad-hoc hybrid project architectures. Further analysis of the factors gave me more understanding about their nature and relation to the different categories of complexity and volatility (social, knowledge and technical) with a focus on how the PM methodologies address the related risks. As a result, I could identify standard controls and thus start to attribute specific factors to specific project practices and hybridisation.
Chapter 6

Parametrisation of PM processes based on problem characteristics

In this chapter I bring together results from Chapters 4 and 5 in order to provide a way to systematically parametrise PM processes in the face of complexity and volatility, and thus better mitigate the risks arising from them. In particular, I will combine my interpretation of PM as problem solving within POE, from Chapter 4, with my mapping, from Chapter 5, between specific complexity and volatility risk factors and methodological controls from predictive and adaptive PM approaches, in order to formulate general process rules for risk mitigation, to support a systematic PM process parametrisation in the face of complexity and volatility, hence addressing research question:

Q3: How can PM processes be parametrised based on problem characteristics?

The chapter is organised as follows. Section 6.1 introduces control objectives, which are then related to POE in Section 6.2. In Section 6.3 I propose a way to parametrise projects systematically, which I illustrate in Section 6.4. Finally, Section 6.5 concludes the chapter.

6.1 Introducing control objectives for complexity and volatility risks

According to ISO/IEC 27000:2017 (ISO - ISO/IEC 27001 — Information security management), a control objective is a “statement describing what is to be achieved as a result of
implementing controls.”

I analysed the controls discussed in Chapter 5, Section 5.3, based on the way they mitigate risk deriving from related factors (see also Table 2.7 in Chapter 2) and with reference the practitioners’ responses (Tables 5.2 and 5.3 in Chapter 5), to arrive at a number of control objectives relevant to complexity and volatility. For instance, team expertise was mentioned by practitioners in relation to aiding knowledge discovery, hence was grouped under a control objective I called ‘learning’. As a result of this analysis, I identified the following control objectives, with controls grouped as indicated in Figure 6.1:

- **Learning** to promote knowledge discovery, so as to mitigate risks related to information fragmentation by reducing the probability of its occurrence.

- **Communication** to ensure that knowledge is accessible and shared, so as to mitigate risk by preventing the increase of interactions and complicated communication.

- **Structure** to improve the ability to predict behaviour, so as to mitigate risk by reducing the probability of scope creep, specifically in large problems.

- **Risk transfer** to ensure goals remain aligned to stakeholders’ needs and the environment, so as to mitigate risk by preventing goals conflicts or obsolete solutions.

- **Speed** to ensure that delivery takes place in a timely fashion, so as to mitigate risk by reducing the impact of shifting requirements, changes in technology or the environment which would cause the project to fail.

In Section 6.3, control objectives will be considered again in relation to the choice of recommended controls.

Under Communication I grouped predictive controls such as establishing a communication plan and one source of truth, and using explicit documentation, as discussed in Chapter 5 and indicated in Figure 6.1, these mitigate risks related mostly to social complexity, but also to social volatility. Learning combines adaptive and predictive controls which are related primarily to knowledge complexity, but also to volatility. Risk transfer combines predictive controls which can be associated to complexity, with one adaptive control (stakeholder required to identify and agree high priorities first) which is related
### FIGURE 6.1: Control objectives and assigned controls in relation to volatility and complexity dimensions, and factors they apply to

<table>
<thead>
<tr>
<th>Control objective</th>
<th>Control objective</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication</strong></td>
<td>communication plan</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>explicit documentation</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>establish one source of truth</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td><strong>Learning</strong></td>
<td>front-loading the project with knowledge discovery</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>prototyping</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>short and frequent learning cycles</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>team expertise</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td><strong>Risk Transfer</strong></td>
<td>formal quality gates</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>stakeholder management</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>stakeholder required to identify and agree high priorities first</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>stringent governance and accountability</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>scope simplification</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>short and frequent development and feedback cycles</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>verbal communication</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td>decompose into work packages with minimal inter-dependency</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>strict change control</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
<tr>
<td></td>
<td>up-front plan</td>
<td>Complexity, Novelty, Urgency, Uncertainty, Risk, Viable, Underutilised, Technological, Economic, Social, Ethical</td>
</tr>
</tbody>
</table>

Note that each of the groups includes controls derived from both predictive and adaptive methodologies. As such controls within a group are not necessarily interchangeable, and may be mutually exclusive. For instance, verbal communication, a typical adaptive control, is at odd with the use of communication plans or explicit documentation, and also with the use of formal quality gates, strict change control and up-front planning. Similarly, front loading the project with knowledge discovery contradicts the use of short and frequent learning cycles, although both have the same control objective of learning. Some controls, however, such as team expertise or stakeholder management, can be applied in combination with any other control. The same applies to the POE controls, which
I will introduce later in Section 6.3 Figure 6.2 indicates which controls are mutually exclusive or cannot be combined.

This information will be used in Section 6.3 when I consider how to design a project architecture, in order to avoid the introduction of incompatible controls.

<table>
<thead>
<tr>
<th>Control Objectives</th>
<th>Communication</th>
<th>Learning</th>
<th>Risk Transfer</th>
<th>Speed</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls</td>
<td>Communication</td>
<td>Learning</td>
<td>Risk Transfer</td>
<td>Speed</td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>communication plan</td>
<td>explicit documentation</td>
<td>front-loading the project with knowledge discovery</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>establishing one source of truth</td>
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<td>prototyping</td>
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<tr>
<td></td>
<td>explicit documentation</td>
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<td>x</td>
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<tr>
<td>Learning</td>
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<td></td>
<td>short and frequent learning cycles</td>
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<td></td>
<td>team expertise</td>
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<td>Risk Transfer</td>
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<td></td>
<td>formal quality gates</td>
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<td></td>
<td>stakeholder management</td>
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<td></td>
<td>stakeholder substitution</td>
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<td></td>
<td>stakeholder required to identify and agree high priorities first</td>
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<td></td>
<td>stringent governance and accountability</td>
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<td>Speed</td>
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<td></td>
<td>scope simplification</td>
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<tr>
<td></td>
<td>short and frequent development and feedback cycles</td>
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<tr>
<td></td>
<td>verbal communication</td>
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<tr>
<td>Structure</td>
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<tr>
<td></td>
<td>decomposition into work packages with minimal inter-dependency</td>
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<td></td>
<td>risk change control</td>
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<td></td>
<td>up-front planning</td>
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</tbody>
</table>

* X Mutually exclusive controls

**Figure 6.2**: Relationship between controls in the project problem space: indication of mutual exclusion

### 6.2 Control objectives and POE

In this section I consider which elements of POE can contribute to meet the complexity and volatility control objectives I have just defined.

#### 6.2.1 Structure

As discussed in Chapter 4, Section 4.1, the POE Process Pattern (PPP) is the core structuring mechanism for POE problem solving processes, separating out exploration and
validation activities in both problem and solution spaces. In that chapter, I considered how the PPP can be used to shape the process as a trade-off between the knowledge discovery during explorations and the risk reductions occurring at validation points, and thus observed that the relationship and timing between resource consuming problem and solution explorations and risk mitigation through validation is relevant in terms of risk control.

Iterative and incremental processes are accommodated through sequential composition of the PPP, and adaptive processes can be generated by ensuring that at each PPP iteration only part of the need is delivered, assuming the problem can be decomposed in that way.

Indeed, problem decomposition, one of POE’s core transformations, allows the decomposition of a problem into its subproblems, while still accounting for their interdependencies through their shared phenomena: this can help dealing with complexity, particularly technical complexity, while reducing the risk of naive decomposition, as introduced in Section 4.1, with problem diagrams used to identify shared phenomena, hence problem interdependencies and the effect of any change on related problem domains and sub-problems.

In the presence of volatility, whenever possible a problem might be decomposed so that sub-problems corresponding to the most urgent known requirements can be addressed first, with the problem solving process organised in incremental PPP cycles.

In this chapter and the next I will investigate the extent problem decomposition can inform work-package decomposition in the associated projects so as to ensure minimal inter-dependency between those packages and to facilitate change control and the allocation of high-performing sub-teams.

### 6.2.2 Risk transfer

As part of the PPP, validation points help transfer the development risk among stakeholders. The risk of committing resources to poorly understood problems, for instance, will be reduced if the appropriate stakeholder validates problem understanding early on, which will contribute to agreeing priorities first and reducing stakeholder goal conflicts.
In the choice of identifying relevant stakeholders, problem diagrams have a role to play in finding possible problem tangles through shared phenomena, hence informing which stakeholders are affected by the changes, and thus should be involved at each point in the process.

In support of stakeholder management, stakeholder substitution, another POE transformation, allows one to replace a validating stakeholder based on organisational and governance roles, influence or other significant relationships, for instance, delegating validation tasks to organisational units closer to the problem.

As I will see, validation checks can be related to formal quality gates between corresponding project phases.

### 6.2.3 Learning

Problem and solution explorations have the purpose to gain knowledge and are thus related to learning. For new or poorly understood problems, appropriate problem exploration will mitigate the risk of moving to solution prematurely, which may lead to unfit-for-purpose solutions and wasted resources.

In the case of changing knowledge, iterative short phases of problem and solution explorations will ensure that the learning process continues throughout, and thus reduce the probability that either the requirements or the impact of the solution are not properly understood.

### 6.2.4 Communication

POE encourages the development of problem models whose descriptions can be used both as documentation and for stakeholder communication, while validation checks require the inspection of problem and solution artefacts by stakeholders. The level of detail and the effort required will depend on compliance requirements as well as team and organisational culture: for instance, in a safety critical environment both documentation and validation artefacts may be very detailed (see, e.g., Mannering, Hall, and Rapanotti, 2008), possibly at the level of producing blueprints, while in an agile environment, sketches may be sufficient to support verbal communication.
6.2.5  Speed

The scope of each PPP cycle can be adjusted to deliver the time-critical needs, which will impact the extent and timing of exploration activities, hence the resource consumed, and which validating stakeholder should be involved.

More generally, the timing of each PPP cycle and the frequency of its validation checks will depend on expected volatility across various problem dimensions as I will discuss in Chapter 8.

6.3  Parametrising projects

In this section, I bring together controls and control objectives, indexed by complexity and volatility dimensions, with the key PMBOK concepts I discussed in Chapter 4, Section 4.2, specifically, those of PM process groups and of project life-cycle phases.

At this stage it is important to remark that most of the controls identified in Chapter 5 apply to projects, so, in terms of my POE characterisation of PM, they apply to the project problem (see Chapter 4, Section 4.2). Some, however, can also apply to the organisational problem. As I will see later in Figure 6.4, these are marked with a ‘*’ and are assigned the same number as their project problem counterpart. ‘Problem exploration’ (control 6*) is the counterpart of 6: ‘short and frequent learning cycles’, which apply to the project problem. A similar relationship is applicable to ‘stakeholder management’ in the organisational problem (control 9*) which corresponds to ‘stakeholder management’ in the project problem (control 9), ‘scope simplification’ in the organisational problem (control 12*) which corresponds to ‘scope simplification’ in the project problem (control 12), and ‘decomposition in subproblems with minimal inter-dependency’ in the organisational problem (control 15*) which corresponds to ‘decomposition in work packages minimal inter-dependency’ in the project problem (control 15).

The rules of mutual exclusion defined in Figure 6.2 also apply to the organisational problem controls. Following the behaviour of their counterpart which apply to problems, only controls 6* ‘Problem exploration’ and control 15* ‘decomposition in subproblems with minimal inter-dependency’, cannot be applied simultaneously in a problem step. A
summary of the relationship between the controls applicable to organisational problems is displayed in Figure 6.3.

<table>
<thead>
<tr>
<th>Control Objective</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>6* Problem exploration</td>
</tr>
<tr>
<td>Risk transfer</td>
<td>9* Stakeholder management</td>
</tr>
<tr>
<td>Speed</td>
<td>12* Scope simplification</td>
</tr>
<tr>
<td>Structure</td>
<td>15* Decomposition into subproblems with minimal inter-dependency</td>
</tr>
</tbody>
</table>

![Figure 6.3: Relationship between controls applicable to organisational problems: indication of mutually exclusion](image)

One of my ideas is that project architecture being predictive or adaptive can provide the appropriate measure of control for organisational problem solving risk in the presence of complexity and volatility. Note, however, that complexity and volatility are organisational problem space characteristics and so must be understood before a project architecture can be used to mitigate them.

Another component of this research is the discovery of complexity and volatility as organisational problem solving develops. After all, complexity and volatility are revealed as problem solving progresses.

I have, so far, relied on an unchanging view of complexity and volatility to determine complexity and volatility at each step. Missing from my framework’s presentation has therefore been complexity and volatility discovery steps by which problem space complexity and volatility are discovered. One of the four just introduced problem based controls, ‘Problem exploration’ (control 6*) thus has a double function. On one side it helps to uncover and assess risk arising from any dimension of complexity and volatility, while, at the same time, is a strong mitigation against knowledge complexity and knowledge volatility, and a weak mitigation against the rest of the dimensions of complexity and volatility.
Control 6* and expert judgement will help to decide when the learning about the problem is enough so as to from the organisational problem space to the project problem space.

Later in Chapter 7, I will elaborate on the effects of applying such controls to the organisational problem.

Figure 6.4 provides a synthesis of how controls can apply to different PM processes and project phases, depending on complexity/volatility dimensions.

The information is arranged in a tabular form, with each row corresponding to a control. Controls are grouped according to their related control objective, and for ease of reference, are assigned a number.

The columns are as follows. Columns ‘Where in life cycle’ and ‘Related PM Process’ relate to the PMBOK phases and process groups where each control is applicable. This information gives the possibility to refer additionally to the PMBOK framework for hints on how to execute the controls specifically. Both columns are marked as ‘n/a’ (non applicable) when controls not are applicable to the project problem.

Columns ‘Impact on Budget’, ‘Impact on Scope’ and ‘Impact on Schedule’ provide an indication of the impact of the control on the key performance indicators of the iron triangle (see Chapter 2 Section 2.3). A ‘-’ with reference to budget, for instance, means that there is a negative impact on budget, therefore the control requires more resources, while a ‘+’ means that there is a positive impact on budget, hence fewer resources are required. Similarly, a ‘-’ in impact on schedule means that more time will be needed, while a ‘+’ that time will be saved. In the case of scope, a ‘-’ means that less scope is delivered, while a ‘+’ that a super set of requirements can be satisfied by the delivered scope. It is important to note that for the same control the impacts on budget and schedule may balance each other out, so that trade-offs may be possible depending on resource availability.

For the controls which are applicable to the organisational problem, I extended the iron triangle, so that to use the key performance indicators budget, scope and schedule to describe the impact of the control on the those problems. Accordingly, impact on budget refers to the resources spent in exploration and validation, impact on scope refers to the extent to which the need is satisfied and impact on schedule refers to the time needed for exploration.
### Chapter 6. Parametrisation of PM processes based on problem characteristics

**Figure 6.4: System to map risk controls to complexity and volatility dimensions**

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<thead>
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</thead>
<tbody>
<tr>
<td>Communication</td>
<td>1</td>
<td>Plan Communication</td>
<td>Organising and preparing</td>
<td>10.1, 10.2, 10.3</td>
<td>-</td>
<td>Solution validation</td>
<td>$A$</td>
<td>$A$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Establishing one source of truth</td>
<td>All phases</td>
<td>4.1, 4.4</td>
<td>-</td>
<td>Solution exploration</td>
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<td>$A$</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>3</td>
<td>Explicit documentation</td>
<td>All phases</td>
<td>4.1, 4.4</td>
<td>-</td>
<td>Phenomena description</td>
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<td>$A$</td>
<td>$G$</td>
<td>$R$</td>
<td>$R$</td>
<td>not possible if volatility</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Learning</td>
<td>4</td>
<td>Front-loading the project with knowledge discovery</td>
<td>Starting the project</td>
<td>5.1, 5.2, 5.3, 5.4</td>
<td>+</td>
<td>Solution exploration</td>
<td>$G$</td>
<td>$R$</td>
<td>$R$</td>
<td>not possible if volatility</td>
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<tr>
<td></td>
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<td>Prototyping</td>
<td>Organising and preparing, Carrying out the work</td>
<td>5.4 and 6.1 to 6.5</td>
<td>-</td>
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<td>$G$</td>
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<tr>
<td></td>
<td>6</td>
<td>Short and frequent learning cycles</td>
<td>Organising and preparing</td>
<td>6.1, 5.2, 5.3, 5.4</td>
<td>-</td>
<td>Short PPP cycle (solution exploration)</td>
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<td>$A$</td>
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<td>7</td>
<td>Problem complexity ($)</td>
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<td>$A$</td>
<td>$A$</td>
<td>$G$</td>
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<td>applicable to organizational problem</td>
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<td>8</td>
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<td>All phases</td>
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</tr>
<tr>
<td>Risk transfer</td>
<td>9</td>
<td>Stakeholder management</td>
<td>All phases</td>
<td>13.1 to 13.4</td>
<td>-</td>
<td>Stakeholder identification, sharing of phenomena, solution validation delegation through stakeholder substitution</td>
<td>$G$</td>
<td>$A$</td>
<td>none</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Stakeholder management ($)</td>
<td>n/a</td>
<td>-</td>
<td>Stakeholder identification, sharing of phenomena, problem validation delegation through stakeholder substitution</td>
<td>$G$</td>
<td>$A$</td>
<td>none</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Stakeholder required to identify and agree priorities</td>
<td>Starting the project, Organising and preparing</td>
<td>13.2, 13.3, 5.1, 5.4</td>
<td>+</td>
<td>Problem &amp; solution validation</td>
<td>$G$</td>
<td>$A$</td>
<td>$A$</td>
<td>none</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>12</td>
<td>Scope simplification</td>
<td>Organising and preparing</td>
<td>5.1, 5.2, 5.3, 5.4</td>
<td>+</td>
<td>Solution interpretations</td>
<td>$G$</td>
<td>$A$</td>
<td>$G$</td>
<td>forces to negotiate but helps for volatility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Scope simplification ($)</td>
<td>n/a</td>
<td>-</td>
<td>Problem interpretations</td>
<td>$G$</td>
<td>$A$</td>
<td>$G$</td>
<td>applicable to organizational problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Short and frequent development and feedback cycles</td>
<td>Organising and preparing, Carrying out the work</td>
<td>5.4 and 6.1 to 6.5</td>
<td>-</td>
<td>Short PPP cycle, validation delegation through Stakeholder substitution</td>
<td>$A$</td>
<td>$A$</td>
<td>$G$</td>
<td>$G$</td>
<td>$G$</td>
<td>depends on possibility of partial delivery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Verbal communication</td>
<td>All phases</td>
<td>4.2, 4.3, 4.5</td>
<td>-</td>
<td>Constraints on exploration and validation</td>
<td>$R$</td>
<td>$R$</td>
<td>$R$</td>
<td>$A$</td>
<td>$A$</td>
<td>none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td>16</td>
<td>Decomposition into work packages with minimal inter-dependency</td>
<td>Organising and preparing</td>
<td>5.4 and 6.1 to 6.5</td>
<td>-</td>
<td>Solution decomposition, identification of sharing of phenomena and tangling</td>
<td>$G$</td>
<td>$G$</td>
<td>$G$</td>
<td>$G$</td>
<td>$G$</td>
<td>risk of nexus decomposition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Decomposition into subproblems with minimal inter-dependency ($)</td>
<td>n/a</td>
<td>-</td>
<td>Problem decomposition, identification of sharing of phenomena and tangling</td>
<td>$A$</td>
<td>$A$</td>
<td>$A$</td>
<td>$A$</td>
<td>$A$</td>
<td>$A$</td>
<td>applicable to organizational problem</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Direct change control</td>
<td>All phases</td>
<td>4.1, 4.6</td>
<td>-</td>
<td>Backtracking with further interpretation and validation</td>
<td>$A$</td>
<td>$G$</td>
<td>$G$</td>
<td>$G$</td>
<td>$G$</td>
<td>depends on controllability of risks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Up-front plans</td>
<td>Organising and preparing</td>
<td>4.2</td>
<td>-</td>
<td>Solution exploration in PPP</td>
<td>$G$</td>
<td>$R$</td>
<td>$R$</td>
<td>$R$</td>
<td>$R$</td>
<td>not possible if volatility or knowledge complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**References:**
- $G$: Strong mitigation
- $A$: Weak mitigation
- $R$: Mitigation to be avoided
- ($) added controls which can be applied to the organisational problem
Chapter 6. Parametrisation of PM processes based on problem characteristics

The ‘POE concept’ column identifies POE concepts which are related to the controls, as explained Section 6.2.

The six columns, related to the six complexity and volatility dimensions, indicate to which extent each control mitigates risks arising from them, using a RAG rating (Red, Amber and Green): green (G) indicates strong mitigation; amber (A), weak mitigation; and red (R) means that the control should be avoided. In cases where the control does not apply, the corresponding cells are left empty.

The last column, ‘Constraints’, provides further guidance for the selection of controls in relation to:

- controls to be avoided: for instance, explicit documentation is not indicated for volatility;
- effect on project performance: for instance, scope simplification has a negative impact on scope, but is a strong mitigation in the case of volatility
- nature of the control: for instance, ‘team expertise’ can only be applied if experts are available.

Both RAG rating and guidance are based on the practitioners’ responses (see Tables 5.2 and 5.3 in Chapter 5), as well as the author’s own experience as a PM practitioner.

Our synthesis in Figure 6.4 supports a method to select systematically controls in the presence of complexity and volatility. It is important to remark that prior to the selection of the controls, it is necessary to:

1. understand the organisational problems to be solved by the project;
2. identify and assess the factors that drive risk related to complexity and volatility.

It is important to remark the steps previous to the application of the framework: understanding the organisational problem and identifying and assessing the factors that drive risk related to complexity and volatility will always require ‘iteration’ so that ‘do problem exploration’ (control 6*) until you have learned enough to proceed. In the end, the amount of exploration will be given by the equation between accepted risk and resources consumed by the exploration. I will exemplify this concept in Chapter 7.
Returning to the framework, let us assume, for instance, I want to select the best applicable controls in the presence of technical complexity after having executed the necessary steps to understand the organisational problem and assessed the related risk. I proceed as follows:

1. I consider all the controls which strongly mitigate (‘G’ in the table) risk from technical complexity. If I am in the organisational problem step I will only consider the starred controls. In this example, the selected controls are (see Figure 6.5): scope simplification (both in the organisational and project problem step, controls 12* and 12), decomposition (both in the organisational and project problem step, controls 15* and 15) and up-front plans (17).

2. I check whether the controls are mutually exclusive (see Figure 6.2): should that be the case, different subsets would have to be considered in turn to choose combinations which both mitigate risk and have an acceptable impact on the project.

3. I focus on the controls which are more likely to successfully mitigate the risk based on the characteristics of the problem. In this example scope simplification (12 and 12*) has the control objective ‘speed’, while the rest of controls have the control objective ‘structure’.

4. I evaluate their impact on project performance, specifically on budget, scope and schedule. While scope simplification has a positive impact on budget and schedule, it has a negative impact on scope, which would have to be negotiated with stakeholder. The two other controls, on the other hand, have a negative effect on both budget and schedule, which would also need to be considered.

5. I consider any additional information that might affect the choice of controls, such as the phases and processes they apply to. The first two, 12 and 15, apply to both organisational and project problems; while, the last one, 17, only to the project problem. All three apply during the organising and preparing phase and relate to different PM processes applicable during that phase. I also consider how these controls affect other dimensions of complexity and volatility or there are constraints related to their nature. Up-front plans (17), for instance, is to be avoided in case of technical
volatility, and knowledge complexity and volatility while decomposition into work packages with minimal inter-dependency has the risk of naive decomposition, which needs to be taken into account.

In case that a problem presents characteristics of more of one dimension of complexity and/or volatility at the same time, the steps need to be repeated for each of the dimensions while considering possible effects on the rest. For instance, would a problem present characteristics of technical complexity together with knowledge volatility at the same time, when selecting the controls, it would be necessary to evaluate if the possible controls mutually exclude or if the selected controls for a dimension are either not recommendable (R) or a weak mitigation (A) for any of the others.

In the next section, I exercise this method on an illustrative example, also addressing what should happen in the presence of more than one dimension of complexity and volatility.

### 6.4 Illustrative case study

In this section, I return to the case study I used in Chapter 4, Section 4.3, to illustrate how my proposed approach can be used to shape a project architecture. I also use the case study to provide an initial assessment of the extent my method aligns with practices on a real-world project. I do a further assessment in Chapter 7.

I proceed as follows. I identify and represent the complexity and volatility characteristics of each organisational problem on the left-hand side of the design tree of Figure 4.14. I then identify the controls which were applied in the project at each step and how they contribute or not to the successful solution of the organisational problem. In parallel, I apply my method to identify which controls should apply at each step, and compare the outcome with what happened in the real-world project.

In order to support the application of the method, I encoded the table in Figure 6.4 within Tableau, a well known data analysis and visualisation tool, in order to semi-automate some of the steps and reduce the incidence of human error in applying the procedure.

1[https://www.tableau.com]
Figure 6.5: Best applicable controls in case of technical complexity
6.4.1 Analysis of complexity and volatility

I started by reviewing the characteristics of complexity and volatility for each organisational step: the outcome is recorded in Figure 6.10. In this case study, only complexity dimensions were identified.

I augmented the design tree representation of Figure 4.14 to capture complexity characteristics as indicated in Figure 6.6: each organisational problem is colour-coded depending on the complexity dimension identified. In the case of a problem exhibiting more than one complexity dimension, a pie chart-like representation was adopted, meant as a visual clue, with no numerical quantification attached: for instance, P2 exhibits complexity alongside all three dimensions, i.e., social, technical and knowledge. In Chapter 8 I will address the quantification of complexity and volatility as part of future work.

6.4.2 Applied vs recommended controls

For each organisational problem, I identified the controls applied in the project in relation to identified risk to be mitigated, and compared them with those recommended by the method.

P1 This organisational problem presented characteristics of knowledge complexity. A project was set up to solve the problem. This is an expert judgement and not part of the method. The actual control applied during the first project problem step (PP1) was ‘team expertise’, consisting of asking a team of experts to evaluate the first candidate solution, which led to discarding this solution early on, mitigating against the risk of investing substantial resources in the wrong solution.

To identify the controls recommended by the method, I applied the procedure outlined in the previous section to P1. Briefly:

1. I considered the controls with strong mitigation (G) against knowledge complexity (see Figure 6.7) and identified controls ‘front-loading the project with knowledge discovery’ (control 4), ‘prototyping’ (control 5), ‘short and frequent learning cycles’ (control 6), and ‘team expertise’ (control 7);
2. I checked in Table 6.2 if the found controls would be mutually exclusive, in this case control 6 excludes mutually with controls 4 and 5;

3. I considered the related control objective (in this case all have the control objective learning, which is more likely to mitigate the risk based on the characteristics of the problem);
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4. I evaluated their impact on budget, scope and schedule;

5. I considered the phases and processes they apply to (in this example, P1 is to be solved by a project problem PP1, whose first step corresponds to starting the project phase), and I considered any additional constraints.

As a result of this analysis, I focused on two controls: ‘Front-loading the project with knowledge discovery’ is applicable in the starting phase (control 4) while ‘team expertise’ (control 7) is applicable during the whole life cycle. The former has a negative impact on schedule and cannot be used if there is a possibility of volatility (which might act as a prompt for more problem exploration to check), while the latter has a positive impact on schedule, but can only be applied if expertise is available. In this case, the recommended set of controls includes the one which was successfully applied in the project.

P2  This organisational problem presents characteristics of knowledge, technical and social complexity. As in P1, a project was set up to solve P2. As I saw in Chapter 4, there were four related project steps (PP2 to PP2.3) which covered the phases: starting the project, organising and preparing and carrying out the work. The actual controls applied in the project were many and included: ‘front-loading the project with knowledge discovery’ (during the starting phase), ‘stakeholder management’ (throughout the whole project), ‘decomposition into work packages with minimal inter-dependency’ (at the organising and preparing and carrying out the work phases), and ‘formal quality gates’ (throughout the whole project). As I discussed in Chapter 4, the actual outcome was
negative, as the solution was rejected by the affected stakeholders but only after implementa-
tion, hence with considerable waste of resources.

In order to identify the recommended controls, the combination of three different di-

censions of complexity required me to repeat the steps outlined above for each of the di-


mensions while considering possible effects on the rest.

In this example, I started my analysis with knowledge complexity (note that I could have started with any other dimension).

From the application of the steps, I arrive at the same results as in P1: ‘short and fre-

quent learning cycles’ (control 6) excludes mutually with ‘Prototyping’ (control 5) and ‘front-loading the project with knowledge discovery’ (control 4). Prototyping’ (control 5) has a positive impact on scope but a negative on budget and schedule and, additionally, is a weak mitigation against social and technical complexity. ‘Short and frequent learning cycles’ (control 6), similarly, has a positive impact on scope and negative on budget but is neutral in relation to schedule. ‘Front-loading the project with knowledge discovery’ is applicable in the starting phase (control 4) while ‘team expertise’ (control 7) is applicable during the whole life cycle. ‘Prototyping’ (control 5) and ‘short and frequent learning cycles’ (control 6) are applicable in the organising and preparing phase. Control 4 has a negative impact on schedule and is not possible to use if there is a possibility of volatility. Furthermore, control 7, which is additionally a weak mitigation against technical complexity, will depend on resources availability.

I continue with technical complexity and repeat the same steps as for knowledge com-

plexity. In Figure 6.8 I can see the results of the application of the steps.
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FIGURE 6.9: Selection of applicable controls in P2 for social complexity

‘Scope simplification’ (control 12), ‘decomposition into work packages with minimal inter-dependency’ (control 15) and ‘up-front plans’ were selected (control 17). All of them apply in the Organising and preparing phase. Control 17 was discarded because it cannot be used in case of knowledge complexity. Control 12 has a positive effect on budget and schedule but negative on scope therefore requires to negotiate with stakeholder but helps with volatility as its control objective is speed. ‘Decomposition into work packages with minimal inter-dependency’ (control 15) has the risk of naive decomposition, therefore exploration of shared phenomena is needed to reduce risk.

Next I repeated the analysis for social complexity. ‘Formal quality gates’ (control 8) and ‘stakeholder management’ (control 9) were selected. Both are related to the control objective ‘risk transfer’ and apply to all project phases and have negative impact on budget and schedule and positive on scope, therefore both could be applied simultaneously if there is a decision to invest the necessary time and resources. There is no interaction between the controls and knowledge and technical complexity.

Finally, I checked the table displayed in Figure 6.2 to find any mutual exclusion between all the selected controls. As already mentioned, short and frequent learning cycles (control 6) is incompatible with front-loading the project with knowledge discovery (control 4) and formal quality gates (control 8), thus was not considered within the list of recommended controls.

In summary, for P2, where there is more than one dimension of complexity, the recommended controls are the set of controls which:

1. mitigate the complexity dimensions identified;

2. are not mutually exclusive; and
3. are not contraindicated for any of the other dimensions to be mitigated.

Therefore, the recommended controls were:

- front-loading the project with knowledge discovery during the starting phase and / or team expertise during all phases (depending on availability of experts) together with prototyping;
- decomposition into work packages with minimal inter-dependency and / or scope simplification for technical complexity, considering the risk of naive decomposition or the possibility to negotiate the scope with the stakeholder; and
- stakeholder management and / or formal quality gates for social complexity during the whole project, individually or combined depending on the availability of time and budget.

In general, several scenarios are possible for P2, depending the severity of the complexity present, the willingness to spend more time and budget or to negotiate the scope, and the availability of resources.

The controls applied in the real life project (equivalent to front-loading the project with knowledge discovery, stakeholder management and formal quality gates, and decomposition into work packages with minimal inter-dependency) matched those recommended by the method but were insufficient, and the actual outcome of the project was negative, as the technical complexity was underestimated, leading to an underestimation of the impact on the affected stakeholders who rejected the solution. Applying control 6* (problem exploration) may have helped to overcome this deficiency. In Chapter 7 I will augment my method adding an initial step for the assessment of risk characteristics of complexity and/or volatility.

**P3 and P4** The same procedure was applied to P3 and P4.

P3, whose solution alternative was ‘to build own central system, with harmonisation of data and processes and with data converter to subsidiaries’ local configurations’, needed to be evaluated by means of a project (PP3). P3 presented characteristics of technical complexity.
In the starting phase, to evaluate the candidate solution and to collect knowledge, team expertise, consisting of asking a team of experts, was proposed and applied successfully. As in P1, it led to discarding this solution early on, mitigating the risk of investing substantial resources in the wrong solution.

In order to identify the recommended controls, I started to look for the controls which were a strong mitigation against technical complexity. The controls found: up-front plans, scope simplification and decomposition in work packages with minimal inter-dependency, which were all applicable during the organising and preparing phase. In order to find a control which could be applied during the starting phase, controls which are a weak mitigation against technical complexity were considered. The selected controls, which were applicable in all project phases were: establishing one source of truth, explicit documentation, team expertise and formal quality gates. Finally, based on the characteristics of the problem that requires the control objective ‘learning’, the selected control was ‘team expertise’ as it is the only one mitigating technical complexity, that is related to the control objective learning.

In P3 I observed how the positive result of the mitigation was in alignment with the recommended control.

In the solution of P4, the applied controls were: team expertise, stakeholder management and quality gates, and scope simplification and decomposition into work packages with minimal inter-dependency. The reason for the success of the solution in the real life project was that technical complexity was so high that only by simplifying the scope made it possible to implement an acceptable solution.

P4 presented the same characteristics as P2, therefore the same reasoning for the selection of the recommended controls applied. As in P3, I could observe how the positive result of the mitigation was in alignment with the recommended controls.

Figure 6.10 summarises, for each problem step, the characteristics of complexity or volatility present, the recommended controls according to the method and their rationale, the actual controls applied in the project and the actual project outcome.
Figure 6.10: Retrospective case study: problem steps, identification of characteristics of complexity and volatility, controls according to model, actual controls applied and project outcome

6.4.3 Discussion

This case study has enabled me to test my method and compare its recommendations with what happened in the real-life project.

Using the table introduced in Figure 6.4, I identified the recommended controls for each of the identified problems, and noted that to a great extent they matched the actual controls applied in the project.

I also observed that, even when the right controls were applied, if not applied correctly, a project step could fail, as demonstrated in P2, where the incomplete mitigation of knowledge complexity resulted in insufficient understanding of the technical complexity of the solution and stakeholders that were not considered earlier in the validation, both
leading to the rejection of the first implemented solution.

The failure of P2, however, acted as a sort of problem exploration which contributed to reduce the knowledge complexity at P4 by exposing technical complexity. Scope simplification in combination with better stakeholder management, achieved to reduce technical complexity, and, at the same time, mitigate social complexity.

When many controls are recommended, it is important to consider the impact in terms of the iron triangle. Controls may compensate for each other (as in P4: scope simplification and stakeholder management), or reinforce each other, meaning that there is a conscious decision to apply similar controls simultaneously in spite of their impact on scope, budget or schedule (as in P2 ad P4: formal quality gates and stakeholder management).

The case study showed that, in the presence of different types of complexity, the controls required for each type of complexity can be applied at the same time as long as they are not mutually exclusive or contraindicated for any of the dimensions of complexity present.

As this case study only presented characteristics of complexity, I could not observe how the method performs in the presence of volatility. Moreover, all the controls considered were applied to the project problem (in the solution space). In Chapter 7 I will consider a more comprehensive case study to test all aspects of my proposed method.

6.5 Summary

In this chapter I have defined a method for the systematic parametrisation of PM processes in the face of complexity and volatility, to better mitigate the risks arising from them, starting to address research question:

Q3: How can PM processes be parametrised based on problem characteristics?

In Section 6.3 I detailed the procedure to apply, which I illustrated on a case study in Section 6.4, providing an initial, partial test of the method. Only complexity dimensions were considered in the case study, and controls were only applied retrospectively to the project problem.
In the next chapter, I provide a fuller evaluation of the method. In particular, in Section 6.3 I described how POE concepts relate and support the application of controls also for the organisational problem steps and can shape the architecture of the project problem steps. In the next chapter I will evaluate the application of such controls.
Chapter 7

Evaluation

The aim of this chapter is to provide validation of the ideas developed in the dissertation, including both the POE interpretation of PM concepts from Chapter 4 and the PM parametrisation method from Chapter 6.

This chapter is organised in two parts:

- a case study from my professional practice;
- a practitioner evaluation.

Together, case study and practitioner evaluation, contribute to address research questions:

Q1: How can PM concepts be interpreted in POE?

and

Q3: How can PM processes be parametrised based on problem characteristics?

Differently from the previous retrospective case study, the case study in this chapter concerns a live project which ran in parallel with the development of the research, so that I was able to maintain a detailed account, in the form of a diary, of each project step.

In Section 2.3.1 I discussed how project managers plan and implement risk control strategies based on their experience and personal preferences, but not from a contextual characterisation (Fan, Lin, and Sheu, 2008). The Project Management Institute (2017a), in particular, recommends explicitly expert judgement and interpersonal team skills as tools to choose risk response. In contrast, my approach to controlling risk is to define risk
controls using organisational problem characteristics, making it novel according to the literature reviewed so far. Although it may appear to share expert practitioners’ judgement and personal preferences, in actuality it is a systematic method which provides objective decision paths to choose risk controls. When these match expert practitioners’ judgement and personal preferences, there is an overlap. Indeed I would not expect to discard expert judgement in the control of risk, simply to systematise it, to augment it, and make it available to others intending to manage project risk.

The chapter is organised as follows. Section 7.1 is dedicated to the case study, Section 7.1.1 providing an overview on the case study, and Section 7.1.1.3 giving its POE interpretation in terms of the PPP and the overall design tree, reconstructed from the project steps in the diary. In Section 7.1.2.2 I apply the method introduced in Chapter 6 for project parametrisation, deriving the controls suggested by the method and comparing them with those applied in the live project. Section 7.2 is dedicated to the practitioner evaluation which is based on the experts’ application of the method to a project they worked on recently. Section 7.3 brings the findings together, with Section 7.4 concluding the chapter.

7.1 Evaluation through a case study

7.1.1 Case study overview

7.1.1.1 The organisational problem

The case study is a complex and volatile business problem including a company acquisition and subsequent integration, solved by means of a complex hybrid project. In summary, Company A wants to grow into (for them) a new market which is predicted to grow rapidly and so already highly competitive. After an initial evaluation of different alternatives, Company A decides to acquire Company C from Company B (see Figure 7.1). The case study focuses on the acquisition and integration of Company C into Company A.

Company A is an established medium-size (family owned) multi-national company, market leader in one specific product type and market segment. Business processes and systems applications were developed centrally to deal with Company A’s core business. 35 subsidiaries, albeit with some local adaptations, share the same system and processes,
FIGURE 7.1: The relationship between Companies A, B and C before the acquisition (right) and after the acquisition (left)

thus change to central systems and processes is not desirable, potentially putting the operation at risk. Additionally, being through a process of internal reorganisation, Company A has a complex - and changing - organisational structure.

Company B is a medium-size company domiciled in another country, which has evolved from its innovative, diverse start up states to be a more traditional company. As a result of this, Company B decided to split part of its product range, that not belonging to its core business, into Company C as a spin off, for quick sale.

The newly created Company C is still dependent on the mother Company B in terms of organisational structure, business processes and systems and has not the necessary size to operate alone. Company C has the expertise on the specific market and products where Company A wants to grow.

Both Company’s B contractual requirements to complete Company C’s separation at a short notice and the impossibility of Company C to operate independently are the main sources of urgency for the project.

The project to integrate Company C into Company A’s processes and systems followed a hybrid approach: the overarching methodology was predictive, following Company A’s usual approach, while the development of new functional capabilities followed an adaptive approach. For speed, as in previous Company A projects, the project was structured into different work-streams according to the business function they related to (e.g. sales, purchasing, etc.). These work-streams worked relatively independently on their assigned work packages, which were consolidated at pre-defined project steps, such as integration testing or ‘go-live’ preparation.

The project took place in the country in which Company C operates, with the project team and project manager working for Company A. Both, the project team and project
manager were experts and had many years’ experience in rolling out the existing processes and systems. The author has not direct influence on the project outcome but had access to all relevant information as a member of the project’s steering committee.

In my account of the case study in this chapter I focus in particular on the project aimed at integrating Company C’s processes and systems into those of Company A. However, for completeness, I have also captured the most significant steps leading to the project.

7.1.1.2 Methodological considerations

This project was chosen as a case study by the author, a programme manager in Company A at the time, as it addressed an organisational problem with both complexity and volatility characteristics. Although the author did not manage the project herself, her membership of the steering committee for the project allowed her to make direct observations and collect data concerning both project steps and the rationale behind project decisions. Additionally, with permission from the organisation, she had access to project documentation, its team members and project stakeholders.

The observations were recorded in a diary as events occurred, starting with the kick off of the first activity where the author was directly involved, which had the objective to explore how to integrate Company C’s processes and systems into those of Company A (July, 2018), and ending with the go-live of the related project (March, 2019). Key decision points related to events that took place before the start of data recording such as the acquisition of Company C in June 2018, were documented at the start of the data collection.

The diary was kept as an Excel spreadsheet, and annotations relevant to the research were added as events unwound, such as the kick off or closing of a project phase, or any specific issue brought by the project team to the author as member of the steering committee. The spreadsheet included the columns shown in Figure 7.1 which form two groups (lost in the spreadsheets structure):

- date of recording, project phase, description of what was observed (captured on the day of the event); and
• as soon as possible after, the author’s related reflection, observed characteristic of complexity and volatility, related POE element, as soon as possible, based on the observations already captured.

7.1.1.3 Problem oriented characterisation

The approach and method discussed in Section 4.2 were used to capture each significant project step as a POE problem based on the content of the diary, after its completion. Specifically, the separation of organisational problems steps and project problem steps followed the approach applied to the retrospective case study in Chapter 4. The full characterisation as problems appears in Appendix C Section C.2.1.

As denoted in Section 4.3, I use labels P1, P2, etc. for organisational problems, and labels PP1, PP2, etc. for project problems, with numbering providing the correspondence between the two: for instance PP9 is the project problem associated with P9. Note that, due to the detail of the information obtained and displayed, this correspondence does not apply rigorously to problems starting in P10, although later I show how such a correspondence can be retrieved.

7.1.1.4 Design tree and commentary

Later in this section I will compare steps suggested by the method of Chapter 6 with the project diary. To do so, it will help to have a design tree, built as a graphical representation of the problem steps captured from the diary. The design tree is shown in Figure 7.2 as constructed below, with Table 7.2 containing relevant parts of the organisational problems for reference.
Figure 7.2: Organisational and project problem steps depicted as a design tree (for sake of simplicity, there is no explicit indication of problems validated successfully)
As defined in Chapter 4, the design tree separates organisational problems to the left from any corresponding project problems to the right.

Problem solving starts with P0. P0 is the need ‘to understand how Company A should grow’ in the context of the ‘target market sector’. As a result of a decision process to which the author did not have access, due to company policy, P0 resulted in P1, whose need is ‘to acquire and integrate Company C’ in the context of the ‘Companies A, B and C’. The solution exploration in P1 led to the decomposition into the subproblems P2, P3 and P4, as follows. P2’s need is ‘to acquire C under the right conditions’ in the context of ‘Companies A, B and C, acquisition laws’. Its solution was reached via project problems steps PP2.1 to PP2.4, whose deliverable is the signed contract between Company A and Company B (the seller) to acquire Company C.

As can be seen in Figure 7.2, P3 and P4 are tackled in parallel, independently from each other. P3’s need is ‘to integrate Company A’s and Company C’s organisational structures’ in the context of ‘Companies A and C’ and was solved as via P3.1 to P3.3. Initially, P3.2 with need ‘to find candidates to fill organisational structure’ was solved successfully but was backtracked due to the failure of P3.3, whose need ‘to allow candidate staff members from abroad to start working in Company C’ could not be met. P3.2B and P3.3B were then solved successfully, hence solving P3.

P4 concerned the need to ‘integrate Company A’s and Company C’s business processes’. In order to be solved, P4 was split into subproblems P5, P6, P7 and P8 following Company C’s organisational structure: P5 dealt with Company A’s integration into the regional organisational structure where Company C belong to, P6 and P7 with the integration into two business units covering Company’s C relevant market segments, and P8 with the integration into the different functional departments (e.g., IT, Purchasing, Sales, Logistic, etc.). Although P5.2 and P6.2 were originally solved, they were backtracked due a to change of the need, that motivated to solve P5.3 and P6.3 respectively.

The solution of P8.1, whose need was to define the business plan for all functional departments, was initially not validated completely and led to the parallel problems P8.1B and P9. The business plan for all functions excluding IT processes and applications was defined in P8.1B and implemented in P8.2. P9 concerned the definition and validation
<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Need</th>
<th>Context</th>
<th>Validation status</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>To understand how Company A should grow</td>
<td>Target market sector</td>
<td>Successful</td>
</tr>
<tr>
<td>P1</td>
<td>To acquire and integrate Company C</td>
<td>Companies A, B and C, their infrastructure and business, and international context</td>
<td>Successful</td>
</tr>
<tr>
<td>P2</td>
<td>To acquire Company C at the right conditions</td>
<td>Companies A, B, acquisition laws</td>
<td>Successful</td>
</tr>
<tr>
<td>P3</td>
<td>To integrate Company A and Company C organisational structures</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P3.1</td>
<td>To define organisational structure for company C</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P3.2</td>
<td>To find candidates to fill organisational structure</td>
<td>Companies A and C</td>
<td>Backtracked due to failure P3.3</td>
</tr>
<tr>
<td>P3.3</td>
<td>To allow candidate staff members from abroad to start working in C</td>
<td>Companies A and C, migration regulations</td>
<td>Failed</td>
</tr>
<tr>
<td>P3.2.B</td>
<td>To find new candidates to fill organisational structure</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P3.3.B</td>
<td>To allow new candidates staff members from abroad to start working in C</td>
<td>Companies A and C, migration regulations</td>
<td>Successful</td>
</tr>
<tr>
<td>P4</td>
<td>To integrate Company A and Company C business processes</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P5</td>
<td>To define and implement business plan for region and location</td>
<td>Companies A and C, market</td>
<td>Successful</td>
</tr>
<tr>
<td>P5.1</td>
<td>To define business plan for region and location</td>
<td>Companies A and C, market</td>
<td>Successful</td>
</tr>
<tr>
<td>P5.2</td>
<td>To implement business plan for region and location</td>
<td>Companies A and C</td>
<td>Backtracked to 5.1</td>
</tr>
<tr>
<td>P5.3</td>
<td>To implement business plan for region and location in new location</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P6</td>
<td>To define and implement business plan for division 1</td>
<td>Companies A and C, market</td>
<td>Successful</td>
</tr>
<tr>
<td>P6.1</td>
<td>To define business plan for division 1</td>
<td>Companies A and C, market</td>
<td>Successful</td>
</tr>
<tr>
<td>P6.2</td>
<td>To implement business plan for division 1</td>
<td>Companies A and C</td>
<td>Backtracked to 6.1</td>
</tr>
<tr>
<td>P6.3</td>
<td>To implement business plan for division 1</td>
<td>Companies A and C, new requirements main customer</td>
<td>Successful</td>
</tr>
<tr>
<td>P7</td>
<td>To define and implement business plan for division 2</td>
<td>Companies A and C, market</td>
<td>Successful</td>
</tr>
<tr>
<td>P7.1</td>
<td>To define business plan for division 2</td>
<td>Companies A and C, market</td>
<td>Successful</td>
</tr>
<tr>
<td>P7.2</td>
<td>To implement business plan for division 2</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P8</td>
<td>To define and implement business plan for all functions</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P8.1</td>
<td>To define business plan for all functions</td>
<td>Company A, company C, Market, regional, local and divisional business plans, existing processes and applications in C</td>
<td>Failed</td>
</tr>
<tr>
<td>P8.1.B</td>
<td>To define business plan for all functions except IT processes and applications</td>
<td>Company A, company C, Market, regional, local and divisional business plans, existing processes and applications in C</td>
<td>Successful</td>
</tr>
<tr>
<td>P8.2</td>
<td>To implement business plan for all functions except IT</td>
<td>Companies A and C</td>
<td>Successful</td>
</tr>
<tr>
<td>P9</td>
<td>To define business plan for IT processes and applications</td>
<td>Companies A and C, contract</td>
<td>Successful</td>
</tr>
<tr>
<td>P10</td>
<td>To integrate Company C in Company’s A processes and applications within timeline agreed in contract</td>
<td>Company A, company C, detailed project plan</td>
<td>Successful</td>
</tr>
</tbody>
</table>

Table 7.2: The need and context of the organisational problem steps P0 to 10 (condensed from Appendix C)
of a business plan for the integration of Company C’s IT processes and software applications into Company A within the timeline agreed in the contract. This problem was solved by a project (problem steps PP9 to PP9.4), where the activities corresponding to a complete project life cycle were carried out. P10 dealt with the implementation of the business plan approved in P9 and was solved by PPI0, which was the continuation of the project initiated in PP9. PP9’s deliverable was the project plan to be implemented in PP10. The explorations that took place during the PP9 project problem steps motivated the decomposition of PP10 into project work packages, which were split according to the expertise supplied by the corresponding sub-teams.

In this fashion, PP10 was decomposed into the problems PP11, PP12, PP13, PP14 and PP15, which could be solved independently, and the problems PP16, PP17 and PP18, which needed to be solved one after the other.

For these steps, I observe that the validation of the project deliverables by the relevant stakeholders took place through more or less formal quality gates between corresponding project phases.

This completes the problem oriented characterisation of the case study.

### 7.1.2 Risk analysis and mitigation

In this section I use the POE interpretation of the case study to apply the procedure described in Chapter 6 Section 6.3 to a) propose controls that mitigate the risks and b) induce a hybrid project architecture.

#### 7.1.2.1 Procedure

I proceed as follows. Starting from the initial organisational problem, I apply successive POE transformations in order to produce a problem solving procedure close to that followed in the real life project.

For each, I apply the framework developed in Chapter 6 to indicate the recommended controls for the organisational problems (in the problem space) and project problems (in the solution space) and describe the resulting project architecture.

As I saw in Chapter 6, the application of controls requires effort which will impact the project budget, scope and schedule. In order to minimise this impact, my method
provides guidance to cut down the controls to a minimum while ensuring that the risk is controlled. In order to do so, I apply the procedure outlined in Section 6.3 so as to determine the best choice for the step. To recap:

1. **Problem exploration** in which I explore the problem in order to gain understanding of the need and context, identify any shared phenomena and tangling, and reveal a problem’s characteristics of complexity and volatility, usually through the application of control 6*;

2. **Choice of candidate controls** I consider the controls with strong mitigation (G) against the identified dimensions of complexity and volatility. Recall that in the case I am in the organisational problem space, I consider only the starred controls (*). The result is a collection of candidate controls to work with;

3. **Mutual exclusion** I check for mutual exclusion between the chosen controls. This reduces the choice to a collection of non-mutually exclusive controls;

4. **Prioritisation** focuses on the controls which are more likely to successfully mitigate risk based on the characteristics of the problem. This is achieved by considering the control objectives related to the candidate controls;

5. **Cross effect** I check if the selected controls have an effect on the mitigation of risk derived from other dimensions. This can reduce the collection of controls by merging those whose effect is duplicated;

6. **Impact** I evaluate the impact of the choice of controls in terms of budget, scope and schedule. This further reduces the collection of candidate controls; and

7. **Feasibility of the choice** I consider any additional information that might affect the choice of a specific control, such as the phase where it is applicable (e.g. control 4 is only applicable in ‘starting the project’), or the content of the field ‘constraints’ (e.g. control 4 is ‘not possible if volatility’).
Chapter 7. Evaluation

At this point I should have a complete minimal collection of controls for risks arising from complexity and volatility, and the sharing of phenomena, for which budget, scope and schedule impact is appropriate.

**Step evaluation** To evaluate the choice of controls, I consider if the problem step, according to the problem oriented characterisation of the diary, was solved successfully or not, and investigate to which extent the application of the controls recommended by the method could lead to this success or give insight into why it actually failed. To do so, I compare the controls recommended by the method with the ones recorded in the diary, expecting to obtain one of these three possible outcomes:

1. results obtained by the application of the method and the ones recorded in the diary are identical, meaning that the controls suggested by the method match the project manager’s expert judgement and/or personal preferences: in this case I can continue with the comparison of the next stage;

2. results obtained by the application of the method and the ones recorded in the diary are not identical but equivalent, meaning that both, the method and project manager’s expert judgement and/or personal preference chose controls which have the same control objective: in this case I can also continue with the comparison of the next stage, perhaps with some minor changes; and

3. results obtained by the application of the method and the ones recorded in the diary are different, meaning that the controls suggested by the method do not match the project manager’s expert judgement and/or personal preferences, leading to a different problem or collection of problems for the analysed problem step: in this case I will attempt to explain the differences before restarting my analysis and move on to the next stage.

In order to differentiate the problem steps recommended by the method from the ones recorded in the diary, I will distinguish the latter by suffixing the letter ‘D’ to the diary entries. P1, for example, corresponds to the architecture generated by the method, while P1D identifies the problem step captured in the diary.
A summary of the procedure and overview of the related sections is shown in Figure 7.3.

**Possible outcomes**

- **Case 1**: Results obtained by the application of the method \((P_x)\) and the ones recorded in the diary \((P_xD)\) are identical.

- **Case 2**: Results obtained by the application of the method \((P_x)\) and the ones recorded in the diary \((P_xD)\) are different leading to a different problem step.

- **Case 3**: Results obtained by the application of the method \((P_x)\) and the ones recorded in the diary \((P_xD)\) are not identical but equivalent.

**Figure 7.3**: Step-wise procedure for evaluation and possible outcomes

Figure 7.4 shows the references corresponding to the representation of the problems developed through the application of the method later in this section.

For convenience, a larger display of the references can be found in Appendix C, Section C.3.1.

**Notes on the procedure** A detailed analysis of the organisational problem steps beginning with \(P_1\) and ending in \(P_4\), \(P_9\) and \(P_{10}\) follows. For brevity I omit certain problem steps when they add no substantive information over the processing of prior steps.

Due to the nature of the data collected, for the problem steps beginning with \(P_5\) and ending in \(P_8\) there is no specific detail of the controls applied and project architecture.
Figure 7.4: References used in the representation of the problem tree according to my method.
More detail of the controls recommended by my method, actual control applied in the diary and project outcome is given in Appendix C, Section C.3.

### 7.1.2.2 Recommended controls and commentary

Although, as a member of the steering committee, the author did not have access to the detailed decision process in P0, I assume that an amount of problem exploration took place in order to gain problem understanding and move from the initial organisational problem P0 ('to understand how Company A should grow’ in the context of the ‘target market sector’) to P1 ('to acquire and integrate Company C’ in the context of the ‘Companies A, B and C’).

**P1** P1 is defined as the need is ‘to acquire and integrate Company C’ in the context of the ‘Companies A, B and C, their infrastructure and business, and international context’.

**Choice of controls** Recall I am assuming I do not know anything about the characteristics of complexity and volatility of the problem. In order to uncover and assess risk from complexity and volatility, I do step **1. Problem exploration** and apply control 6*.

The application of 6* leads to a fuller understanding of the risk related to complexity and volatility and thus reduces the risk associated with not knowing. The identified dimensions of complexity and volatility are: a. social complexity, b. technical complexity, c. knowledge complexity and d. knowledge volatility.

I now apply step **2. choice of candidate controls** to each of the identified risks, beginning with social complexity. As no project has yet begun, I am working in the organisational problem space with the starred (*) controls applicable.

**a. Social complexity** As shown in Figure 7.5 the method indicates the following mitigation against risks resulting from social complexity:

- control 9* (stakeholder management), with negative impact on budget and schedule and positive impact on scope and control objective ‘risk transfer’; and
• control 15* (decomposition into subproblems with minimal inter-dependency) with negative impact on budget and positive impact on schedule and control objective ‘structure’.

![Figure 7.5: P1: Method recommendation for Social Complexity. Please note letter ‘G’ (indication of strong mitigation) in the column social complexity for all displayed controls.]

b. Technical complexity As shown in Figure 7.6, the method indicates the following mitigation against risks resulting from technical complexity:

• control 12* (scope simplification), with positive impact on budget and schedule and negative impact on scope and control objective ‘speed’; and

• control 15* (decomposition into subproblems with minimal inter-dependency) with negative impact on budget and positive impact on schedule and control objective ‘structure’.

![Figure 7.6: P1: Method recommendation for Technical Complexity.]

c. Knowledge complexity As shown in Figure 7.7, the method indicates the following mitigation against risks resulting from knowledge complexity:
- control 6\* (problem exploration), with negative impact on budget and positive impact on scope and control objective ‘learning’.

**Figure 7.7: P1: Method recommendation for Knowledge Complexity**

**d. Knowledge volatility**  Finally, as shown in Figure 7.8, the method indicates the following mitigation against risks resulting from knowledge volatility:

- control 6\* (problem exploration), with negative impact on budget and positive impact on scope and control objective ‘learning’; and

- control 12\* (scope simplification), with positive impact on budget and schedule and negative impact on scope and control objective ‘speed’.

**Figure 7.8: P1: Method recommendation for Knowledge Volatility**

In summary, the list of controls identified as mitigation against the risk resulting from the detected dimensions of complexity and volatility in P1 are: 15\* (decomposition into subproblems with minimal inter-dependency), 6\* (problem exploration), 12\* (scope simplification) and 9\* (stakeholder management), all or any combination of which, are applicable.

Continuing my choice, I do step **3. mutual exclusion** by checking Table 6.3: decomposition into subproblems with minimal inter-dependency (control 15\*) and problem exploration (control 6\*) are mutually exclusive and so cannot be applied on the same problem solving step, forcing me to focus on one of both controls. As a result, I am restricted to
all or any combination of controls 15*, 12* and 9* or all or any combination of controls 6*, 12* and 9*.

Then checking **4. prioritisation**, I see that in P1 the size of the problem requires a control from control objective ‘structure’ as these are specifically applicable to large problems. Of those envisioned so far, only control 15* belongs to the control objective structure.

Then checking **5. cross mitigation**, I see in Figure 7.9 that control 15* controls technical complexity through problem decomposition while identifying the stakeholder(s) that will validate the resulting subproblems, and so also controls social complexity, overlapping with controls 9* and 12*.

Then, checking **6. impact** (on budget, scope and schedule), the decision to apply 9* and 12* or not would come down to budget, scope or scheduling considerations. I assume that there was insufficient budget to apply them all.

Finally, in step 7 **feasibility of the choice**, I validate that there are no relevant constraints.

The chosen control is 15* (decomposition into subproblems with minimal inter-dependency). Although my method does not specify the criteria to be used to apply 15*, it is my assumption that the initial exploration of the problem would allow experts to identify phenomena by which a problem can be decomposed. In this case, I used expert knowledge to choose the nature of the task as criteria for decomposition in subproblems: P2 with the need ‘to acquire Company C at the right conditions’, P3 with the need ‘to integrate Company A and Company C organisational structures’ and P4 with the need ‘to integrate Company A and Company C business processes’.

Finally, and as explained in Section 6.3, control 15* should be followed by control 6* (problem exploration) to assess the transfer of risk resulting from, in this case, P1 to P2, P3 and P4.

On application of 15*, I arrive at the Figure 7.10 which shows the relationship between P1 and subproblems P2 to P4, together with the risk characteristics inherited by P2 to P4. In the problem tree, I see how the application of the chosen controls in the organisational problem space (on the left) uncovers the characteristics of complexity and volatility (by means of 6*) and shapes the problem structure (by means of 15*). As I am still in the
organisational problem space, the right part of the figure, which describes the project problem space, is empty.

**Comparison P1-P1D**  
According to the method, control 6* (problem exploration) should initially be applied to uncover complexity and volatility, then control 15* (decomposition into subproblems with minimal dependencies) is applied to control the resulting risk, followed by control 6* (problem exploration) to uncover the risk transferred to the subproblems which resulted from the decomposition.

From the interpretation of the diary, controls equivalent to ‘stakeholder management’ (equivalent to my control 9*) and ‘decomposition into separate activities with minimal dependencies’ (equivalent to my control 15*) were applied.

As these differ, I am in outcome 3.
Chapter 7. Evaluation

The outcomes differ in the following way. Control 9* was assessed for application as part of social complexity, but control 15* was chosen preferentially due to the problem size. According to the framework, as shown in Table 6.4, the additional application of control 9* has a negative impact on budget and schedule and positive impact on scope.

In the actual project, I note that insufficient learning may have been the cause of underestimation of technical complexity. The extent to which the risk resulting from this complexity and volatility was thus transferred to the subproblems was not systematically addressed either when solving P2, P3 or P4, nor later, in the real project. This underestimation of technical complexity may have led to cascading difficulties during the whole problem solving chain.

P2  A similar procedure was followed for P2.

   P2 is defined as the need ‘to acquire C at the right conditions’ in the context of ‘Company A, Company B and acquisition laws’.

   **Choice of controls**  Beginning with step 1. problem exploration, I use control 6* to reveal the characteristics of a. social complexity and b. knowledge complexity manifested in P2 and to identify shared phenomena and possible tangling.

   As already described in Chapter 6, the application of control 6* and expert judgement help to decide when to move to the project problem space. At this stage, I chose to continue with a project, for which I control the risk. The application of 6* also provides an understanding of the project goals.

   The corresponding project problem is defined as the need ‘to set up a project to collect information about the value of Company C and the feasibility to integrate it to Company A’, in the context of ‘Company A, Company B, and relevant acquisition laws’. Its solution is the ‘signed contract with Company B to acquire Company C’.

   Among the shared phenomena is this signed contract which acts as a constraint in P4 ‘to integrate Company A and Company C business processes’ in terms of setting up the timeline and general conditions for the integration and thus influences the successive development of the design tree.
To manage the project risk, I begin by assuming a generic project life cycle based on the usual phases: starting the project, organising and preparing, carrying out the work and closing.

As I am now in the project problem space, the starred controls do not apply.

I continue with step 2. choice of candidate controls, with a. social complexity and b. knowledge complexity identified in P2, needing to be controlled during the project.

a. Social complexity  As shown in Figure 7.11, the controls applicable to strongly mitigate risk resulting from social complexity in the project problem space are control 8 (formal quality gates) and control 9 (stakeholder management).

b. Knowledge complexity  As displayed in Figure 7.12, the recommended controls to strongly mitigate risk resulting from knowledge complexity in the project problem space are control 4 (front loading the project with knowledge discovery), control 5 (prototyping), control 6 (short and frequent learning cycles) and control 7 (team expertise).
In the evaluation of 3. **mutual exclusion**, I see that control 6 (short and frequent learning cycles) and control 4 (front loading the project with knowledge discovery) are mutually exclusive, while control 8 (formal quality gates) excludes mutually with control 6.

Step 4. **prioritisation** does not allow me to narrow my selection of controls, as all proposed controls that mitigate knowledge complexity belong to learning, while the ones proposed for social complexity belong to risk transfer, and both control objectives are required to control the risks.

There are no 5. **cross effects** to be considered in this case.

In relation to 6. **impact**, control 5 (prototyping) is eliminated due to its negative impact on the schedule.

In relation to step 7. **feasibility of the choice**, control 4 is not possible if there is volatility, and control 7 depends on resources availability. In relation to the project lifecycle, control 6 is recommended in the phases organising and preparing, control 5 in the phases organising and preparing, and carrying out the work, (i.e., both 5 and 6 later in the project), and controls 7, 8 and 9 in all phases.

In summary, after the application of the method, the recommended controls (Figure 7.13) for P2 are: control 9 (stakeholder management), control 7 (team expertise) and control 6 (short and frequent learning cycles) in the project problem space. In Figure 7.13 I describe the project problem steps on the right part of the figure, as a generic project life cycle based on the phases: starting the project, organising and preparing, carrying out the work and closing. Iterations within a phase or between two phases are indicated by the symbol ◯.

**Comparison P2-P2D**  According to the method, control 6* (problem exploration) needs to be applied in the project problem space to learn about the problem and scope the project, together with control 9 (stakeholder management), control 7 (team expertise) and control 6 (short and frequent learning cycles) in the solution space.

From the interpretation of the diary, the equivalent controls identified are: ‘stakeholder management’ (comparable to my control 9), ‘team expertise’ (comparable to my
control 7) and ‘short and frequent learning cycles’ (comparable to my control 6) during the execution of the project.

As these differ, I am again in outcome 3.

The outcomes differ in the following way. Control 6* (problem exploration) in the organisational problem space was not conducted and thus the problem risks were not duly identified.

Should my method have been applied, social volatility, for instance, which was caused by the decision to use an external team that left before the integration of Company C in Company A was finished, could have been identified and mitigated. As this risk manifested, it caused loss of important information that needed to be collected later with the resulting delays and resource expenditure. In the end, unclear contractual agreements led to law suits.

**PP2** The application of 6* could have hypothetically revealed the risk of social volatility, and the application of the method would have indicated how to control this risk (application of step 1. problem exploration).
By applying step 2. choice of candidate controls (Figure 7.14), the method indicates: control 3 (explicit documentation), control 10 (stakeholder required to identify and agree priorities first), control 13 (short and frequent development and feedback cycles) and control 16 (strict change controls) to mitigate the risk resulting from social volatility.

Step 3. mutual exclusion indicates that controls 3 and 16 exclude mutually with control 13.

Finally, already in step 4. prioritisation, control 3 (explicit documentation) can be identified as the only feasible control due to its control objective ‘communication’, which mitigates the risk that knowledge is not lost. The rest of the controls had different control objectives and thus are not applicable.

<table>
<thead>
<tr>
<th>No.</th>
<th>Controls</th>
<th>Control objectives</th>
<th>Impact on budget</th>
<th>Impact on schedule</th>
<th>Impact on scope</th>
<th>Scope</th>
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<th>Technical complexity</th>
<th>Knowledge complexity</th>
<th>Social volat</th>
<th>Technical volat</th>
<th>Knowledge volat</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Explicit documentation</td>
<td>Communication</td>
<td>-0</td>
<td>0</td>
<td>All phases</td>
<td></td>
<td>not possible if volatility</td>
<td>A</td>
<td>A</td>
<td>n/a</td>
<td>G</td>
<td>R</td>
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<td></td>
</tr>
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<td>10</td>
<td>Stakeholder required to identify and agree priorities first</td>
<td>Risk transfer</td>
<td>-</td>
<td>+</td>
<td>Starting the project, Organising and preparing</td>
<td>none</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>G</td>
<td>A</td>
<td>A</td>
<td></td>
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</tr>
<tr>
<td>13</td>
<td>Short and frequent development and feedback cycles</td>
<td>Speed</td>
<td>-</td>
<td>+</td>
<td>Organising and preparing, Carrying out the work</td>
<td>depends on possibility of partial delivery</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>G</td>
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<td></td>
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</tr>
<tr>
<td>16</td>
<td>Strict change control</td>
<td>Structure</td>
<td>-</td>
<td>-</td>
<td>0 All phases</td>
<td></td>
<td>depends on controllability of risks</td>
<td>A</td>
<td>A</td>
<td>n/a</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 7.14: PP2: Method recommendation for Social Volatility**

**P3**  P3 has the need to integrate ‘Company A’s and Company C’s organisational structures’ and in the real life project is addressed by a combination of organisational problems.

I will not describe the process of the selection and comparison of controls in detail, which can be found in Appendix C, Section C.3, as I am again in outcome 3, and a repetition of the analysis does not provide additional knowledge.

However, it is worth commenting on the application of the controls recommended by my method as in P3 I see risk mitigated in the problem space.

In Figure 7.15 I observe how the successive application of the controls avoids that the risk is transferred from one problem to the next. Specifically control 6* (problem exploration) is used initially to explore problem P3, uncover complexity and volatility and mitigate risk related to knowledge complexity. On the application of 6* to P3, I see how
the risk related to knowledge complexity does not transfer to the subsequent problem step P3.1 (indicated in the figure by the change of colours). Similarly, the application of 9* (stakeholders management) in P3.1 avoids that the risk resulting from social complexity transfers to the subsequent problem P3.2, where only the risk of social volatility remains.

P4  P4 has the need ‘to integrate A and C business processes in the context of ‘Company A and Company C’.

Choice of controls  Step 1. problem exploration reveals that P4 inherits from P1 a. technical complexity, b. social complexity, c. knowledge complexity and d. knowledge volatility, as well as shared phenomena. Details are given bellow.

In P4, the characteristics of complexity and volatility of P4 are similar to those assessed in P1, therefore, the process to select the controls is also similar, and I omit it.

Although P4 is a subproblem of P1 it is still quite a large problem that requires ‘structure’ to mitigate risk. Therefore control 15* (decomposition into subproblems with minimal inter-dependency) applies.

As in P1, my method does not specify problem decomposition details and I must look to the project for what occurred. In this case, expert knowledge was used to choose Company A’s and Company C’s organisational structure as criterion for decomposition in subproblems: P5 ‘to define business and implement for region and location’, P6 ‘to define business and implement for division 1’, P7 ‘to define business and implement for division 2’, and P8 ‘to define business and implement for all functions’.

Among the shared phenomena identified are the business plans from the different organisational units which need to be consistent as a whole but are controlled individually by the units. With this tangling of phenomena arises the risk of naive decomposition in P4, to be controlled in the problem steps P5, P6, P7 and P8.

As explained in Section 6.3 control 15* should be followed by control 6* (problem exploration) to assess how risk transfers from P4 to P5, P6, P7 and P8.

Figure 7.15 shows the step between P4 and its subproblem solutions P5 to P8 resulting from control 15*, together with the risk characteristics inherited by P5 to P8, from the application of 6*.
### Figure 7.15: Problem tree with focus on problems P3 and P4, and P4's decomposition into P5, P6, P7 and P8 (⊕ indicates that the problem chains continues)

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Rationale</th>
<th>Project problem</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>n/a</td>
<td>P1</td>
<td>n/a</td>
</tr>
<tr>
<td>P1</td>
<td>5th problem exploration reveals characteristics of complexity and volatility</td>
<td>P2</td>
<td>n/a</td>
</tr>
<tr>
<td>P2</td>
<td>15th initial decomposition following separate phenomena. Not possible to scope a project at that moment</td>
<td>signed contract</td>
<td>n/a</td>
</tr>
<tr>
<td>P3</td>
<td>3 x 0th to reveal inherited characteristics and volatility in P2, P3 and P4 and scope project in P2</td>
<td>controls 7.0</td>
<td>n/a</td>
</tr>
<tr>
<td>P4</td>
<td>6th problem exploration to control KC through exploration of the context</td>
<td>controls 7.0</td>
<td>n/a</td>
</tr>
<tr>
<td>P5</td>
<td>9th stakeholder validation including stakeholder substitution to control SC and SV</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>P6</td>
<td>15th decomposition following separate phenomena</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>P7</td>
<td>4 x 0th to reveal inherited characteristics of complexity and volatility in P5, P6, P7 and P8</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

(⊕ indicates that the problem chains continues)
**Comparison P4-P4D**  According to the method, control 15* (decomposition into subproblems with minimal dependencies) is applied, followed by control 6* (problem exploration) to uncover the risk transferred to the subproblems resulting from the decomposition.

From the interpretation of the diary, control equivalent to ‘stakeholder management’ (equivalent to my control 9*) and ‘decomposition into activities with minimal dependencies’ (equivalent to my control 15*) were applied.

In problem steps P5 to P8, decomposition happens across organisational units, which may treat and control the inherited risk differently.

I conclude in this case, that the results obtained by the application of the controls recommended by the method are equivalent to the ones captured in the diary, i.e., I am in outcome 2.

**P9**  P9 has the need ‘to define business plan for IT processes and applications’ in the context of ‘Company A and Company C and signed contract’.

**Choice of controls**  Beginning with step 1. problem exploration, I use control 6* to gain understanding about the problem, identify any shared phenomena and tangle and identify risk related to complexity and volatility. The identified dimensions of complexity and volatility are: a. social complexity and b. knowledge complexity.

As in P2, the application of control 6* and expert judgement aid to decide when to start a project, for which I control the risk. The application of 6* provides also an understanding of the project goals.

The corresponding project problem is defined as the need ‘to explore viability and obtain approval of proposed business plan for IT processes and applications consisting in the integration of Company C in Company’s A processes and applications within timeline agreed in contract’, in the context of ‘Company A, Company C, and contract’.

To manage this project risk, I begin by assuming a generic project life cycle based on the usual phases: starting the project, organising and preparing, carrying out the work and closing.

As I am now in the project problem space, the starred controls do not apply.
I continue with step 2. **choice of candidate controls**, with a. social complexity and b. knowledge complexity identified in P9, needing to be controlled during the project.

**a. Social complexity** As shown in Figure 7.11 the controls applicable to strongly mitigate risk resulting from social complexity in the project problem space are control 8 (formal quality gates) and control 9 (stakeholder management).

**b. Knowledge complexity** As displayed in Figure 7.12 the recommended controls to strongly mitigate risk resulting from knowledge complexity in the project problem space are control 4 (front loading the project with knowledge discovery), control 5 (prototyping), control 6 (short and frequent learning cycles) and control 7 (team expertise).

In the evaluation of 3. **mutual exclusion**, I see that control 6 (short and frequent learning cycles) and control 4 (front loading the project with knowledge discovery) are mutually exclusive, while control 8 (formal quality gates) excludes mutually with control 6.

Step 4. **prioritisation** does not allow me to narrow my selection of controls, as all proposed controls that mitigate knowledge complexity belong to learning, while the ones proposed for social complexity belong to risk transfer, and both control objectives are required to control the risks.

There are no 5. **cross effects** to be considered in this case.

In relation to 6. **impact**, control 5 (prototyping) is eliminated due to its negative impact on the schedule.

In relation to step 7. **feasibility of the choice**, control 4 is not possible if there is volatility, and control 7 depends on resources availability. In relation to the project lifecycle, control 4 is applicable in phase starting the project, controls 6 and 12 are recommended in the phases organising and preparing, control 5 in the phases organising and preparing, and carrying out the work, and controls 7, 8 and 9 in all phases.

In summary, after the application of the method, the recommended controls (Figure 7.16), for P9 are: control 9 (stakeholder management), control 7 (team expertise) and control 6 (short and frequent learning cycles) in the project problem space.
**Comparison P9-P9D**  According to the method, control 6* (problem exploration) needs to be applied in the project problem space to as to learn and scope the project, together with control 9 (stakeholder management), control 7 (team expertise) and control 6 (short and frequent learning cycles) in the solution space.

From the interpretation of the diary, the equivalent controls identified are: ‘problem exploration’ (comparable to my 6* before scoping the project, ‘stakeholder management’ (comparable to my control 9), ‘team expertise’ (comparable to my control 7) and ‘short and frequent learning cycles’ (comparable to my control 6) during the execution of the project.

I am in outcome 1, as the results obtained by the application of the method and the ones recorded in the diary are identical.

The problem solving activities carried out in P9D were related to the exploration of the need and the context in the organisational problem space. As I will see in the analysis of P10, the learning that took place in P9 provided the basis for the controls applied in the real life project.

**P10**  P10 is the problem step which has the need to integrate Company C in Company’s A processes and applications within timeline agreed in contract in the context of Company A, Company C and the detailed project plan.

In order to apply the method, I need to repeat steps 1 to 8. **Step 1. problem exploration** conducted as a result of P9, revealed that P10 present characteristics of: a. social complexity, b. technical complexity, c. knowledge complexity and d. knowledge volatility. As the characteristics of complexity and volatility of P10 are similar to the ones assessed in P4, I do not need to repeat the choice of control steps 2 to 8.
Control 15* (decomposition into subproblems with minimal inter-dependency) is the chosen control. As in P4, my method does not specify the criteria to be used to apply 15*, however, it is my assumption that the initial exploration of the problem that took place in P9 would allow experts to identify phenomena by which a problem can be decomposed. In this case, I use the nature of the task to be performed to choose the criterion for decomposition in subproblems: P11 ‘to customize Company A’s application and processes to enable Company’s C to operate’, P12 ‘to migrate Company C’s Data into Company A’s applications’, P13 ‘to enable of functionality customer service for Company C’, P14 ‘to implement eCommerce connection to customers according to Divisions’ business plans’, P15 ‘to enable new product development process for Company C in landscape Company A’, P16 ‘to ensure that the implemented solution is stable and works as designed’, P17 ‘to go live’ and P18 ‘to complete activities to be able to close project.’

The processes and functionalities to be implemented in Company C are in this case the phenomena shared between the problems. Validation need to take place to avoid that solving one of the problems would result in constraints to others.

As explained in Section 6.3, control 15* will be followed by control 6* (problem exploration) so that to assess the transfer of risk resulting from, in this case, P10 to P11, P12, P13, P14, P15, P16, P17 and P18.

On application of 15*, I arrive at Figure 7.17 which shows the relationship between subproblems P11 to P18 and P10, together with the risk inherited by P11 to P18. The identification of the controls applicable on the project problem space are available in the Appendix C.

**Comparison P10-P10D** According to the method, control 15* (decomposition into subproblems with minimal dependencies) is applied, followed by control 6* (problem exploration) to uncover the risk transferred to the subproblems resulting from the decomposition.

In the real life project, although the controls were applied in the same way as proposed by my method, they resulted from the experience of the project manager and project team and not from a structured analysis of the characteristics of the organisational problems.
**Figure 7.17:** Problem and project tree with focus on the problems P10 and its decomposition into P11, P12, P13, P14, P15, P16, P17 and P18.
Additionally, formal quality gates (equivalent to my control 7) was applied due to the
difficulty to manage certain stakeholder. The use of the method could have contributed
to make the decision process more transparent and systematic and thus reinforce the
reliability of the project architecture.

The outcome of the step was positive, mostly because already P9 mitigated part of
the knowledge complexity. Formal quality gates, which dedicated additional resources
to mitigate social complexity were conducted, however, stakeholder management was
still an issue during the project.

I presume in this case, that the results obtained by the application of the controls
recommended by the method are the equivalent to the ones captured in the diary, i.e., I
am in outcome 2.

7.1.3 Analysis of findings

Differently from the case study in Chapter 6, I used the initial organisational problem as
starting point applying successive POE transformations in order to simulate the risk mit-
igation part of problem solving. To do this, I applied the method developed in Chapter 6
to indicate the controls that mitigate risk both in the organisational problem (i.e., problem
space) and project problem (i.e., solution space).

For a given risk profile, the method collected candidate controls and refined them
through the steps to a minimum set that treats the known risks.

As input, the method takes the identified risk characteristics and delivers a set of
controls which mitigate these risks. From then on, there is a clear sequence of steps
to prioritise and evaluate the impact of these controls, so that to arrive to a minimal
collection of controls. This makes the method repeatable. The minimal set is never empty
so that suggestions for risk management are always given.

The method is not free standing, but depends on context expertise in two areas: when
problem understanding is required (application of control $6^*$), and when problem decom-
position is indicated (application of control $15^*$).

The distinction between the organisational problem, which requires addressing a spe-
cific organisational need (in POE terms: problem space), and the project problem, which
requires organising the project to deliver the solution to the organisational problem (in
POE terms: solution space), helps me to focus on problem contextual characteristics to identify risk.

For instance, in the problem space, understanding which phenomena are shared helps to visualise how the risk resulting from complexity and volatility is inherited to decomposed problems, such as the contract signed in P2. Likewise, identifying phenomena that tangle helps to uncover the risks associated with naive decomposition, as in the decomposition of P4 into P5, P6, P7 and P8.

The application of the controls, on the other hand, helps also to avoid risk characteristics to be transferred to successive sub-problems. In P3, for instance, the application of control 6* might have mitigated risk related to knowledge complexity so as to avoid it to be transferred to the subsequent problem step, as it happened in the real life project.

The controls that belong to the project problem space are characterised according to the phase in which they are applicable to. This allows me to assign the recommended controls to each phase and to generate hybrid project architectures, such as in P2 and P9, where the application of control 6 (short and frequent learning cycles) generated iterations within a traditional project structure.

In order to evaluate the method, I compared the controls recommended by the method with the ones recorded in the diary to investigate to which extent the application of the controls recommended by the method could lead to success or give insight into why a problem step failed.

In relation to the comparison between the choice of controls according to the method and the choice of controls recorded in the diary, I could find examples of all 3 possible outcomes. In particular, problem 9, which was solved through a project, is an example of outcome 1, where the controls selected by method and the diary are identical. Problem 10, on the other hand, is an example of outcome 2, where the controls selected by method and the diary are not identical but equivalent. In P10, according to the diary, there was a decomposition of the project in work packages (control 15) instead of the problem decomposition proposed by the method (control 15*).

P2 is an example of outcome 3. In P2, the lack of problem exploration in the organisational problem space (control 6*) led to problem risks not being identified. I observe that in this case, although outcome 3 did happen, it was often because a diary step did
not adequately mitigate the risk first time, causing rework (backtracking in POE terms) and application of another control. Whether this is a general property of my method is not yet known.

In each outcome case, I was able, post-rationally, to compare each outcome, (i.e if the controls proposed by the method matched the ones recorded in the diary) with the results obtained in the real life project. I could observe that, in outcome 1 the alignment with practice led to success, in outcome 2 equivalent controls led also to success, and, in outcome 3 the misalignment give a possible explanation for diary recorded failure.

Reflecting on the method, I note that not all controls listed were applied. Some of them, such as control 1 (plan Communication), control 2 (establishing one source of truth), control 11 (stringent governance and accountability) or control 14 (verbal communication), were not chosen as candidates because they were not classified as strong mitigation of any dimension of complexity and volatility that appeared in the problem. A change in the classification of those controls may be considered in future work.

### 7.2 Practitioner evaluation

The aim of the practitioner evaluation was to provide independent validation based on the application of the method to a project they worked on recently, to analyse to which extent the recommendations provided by the method matched the PM’s expectations, and to examine if the procedure was understandable and could be reproduced by someone other than the author.

**Evaluative choices** One way in which the method could be evaluated, would be: 1) to consider all combinations of social, technical and knowledge complexity and volatility, 2) to identify projects that have those characteristics with project managers that have managed them, and 3) to examine whether the method ‘gets it right’. This is an exhaustive evaluation of the method, but would require $64 = 2^6$ example projects (one for each exhibiting social, technical and knowledge complexity and volatility).

A less exhaustive evaluation is to consider fewer example projects and to examine whether the method performs well on these. This is much more feasible and can be completed with fewer project managers. Moreover, given that I do not choose precisely
which projects are tested, the random variation between project managers still exercises
the method.

7.2.1 Interaction

The evaluation of the method was performed online using screen sharing, as, due to the
Covid-19 pandemic, it was not possible to be co-located with practitioners. However,
my growing expertise in the handling of videoconferencing during the crisis overcame to
a great extent the challenges identified in the literature for such interviews (Mirick and
Wladkowski, 2019).

7.2.1.1 General considerations

The practitioner evaluation was performed by via individual online interviews, where
practitioners were requested to apply the method (retrospectively) to a complex project
of their own based on step by step instructions provided on their screen using screen
sharing. Semi-structured interviews were used to investigate a) the applicability of the
method, b) the relevance of the questions used to identify the risk related to complex-
ity and volatility, and c) to which extent the recommendations proposed by the method
would have been suitable to deal with the challenges faced by the real life project.

As at the time the method was being assessed for commercialisation by The Open
University, it was decided to limit the interviewees to experienced, i.e. 5 years’ or more
experience, project and programme managers working for the university itself to avoid
the need for non-disclosure agreements. For practical reasons, it was decided to limit
interviews to one hour. The OU is a large organisation with over 100 concurrent projects
so this did not limit choices excessively.

The evaluation was advertised by OU program managers during their internal PM
meetings, and seven project managers, who had not taken part in the practitioners’ inter-
view described in Chapter 5 volunteered to participate.

In addition, the procedure was tested by two other project managers before the start
of the seven interviews. The tests resulted in changes to the tool in relation to the way
data was displayed. These tests were excluded from the evaluation.
I followed the protocol proposed by Yin (2015), in particular, post-interview responses were to be consolidated in a single spreadsheet. The answers to each question were then classified and grouped following emerging themes to interpret data and draw conclusions.

7.2.1.2 Tool

During the individual online sessions, step by step instructions for using the tool were displayed to the participants via screen sharing, which had the benefits of allowing observation concurrent with its use by the participant. Evaluation of the tool was not a part of the interviews.

Using as a basis the tables in Figures 6.2, 6.4 and 6.3 I developed an interactive Excel spreadsheet to facilitate the application of the method while simultaneously hiding the detail. Differently from the Tableau tool used to select the controls when applying the method to the case studies, this tool gave the possibility to display on one screen the recommended controls for all the dimensions of complexity and volatility identified while, at the same time, showing how the controls mutually exclude, and adding more explicit headlines and colour coding to make it more user friendly. Figure 7.18 shows the screen in case of social complexity and technical volatility.

![Figure 7.18: Information displayed by the Excel tool in case of social complexity and technical volatility, the reader will recognise the content from Appendix D Section D.1.2.2; red and green entries indicate, respectively, negative or positive impact on budget, scope or schedule](image)

7.2.1.3 Questionnaire

A questionnaire based on the description of the complexity and volatility factors from Section 2.2.3 was developed to aid participants identify the complexity and volatility in
the problem and so their related risk. Participants were asked to answer closed questions using their judgement. A quantification or prioritisation of the risk did not take place.

The relationship between the the dimensions of complexity and volatility, the questions and the factors and is shown in Table 7.3.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Question</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Complexity</td>
<td>Would you say the number of stakeholders involved is higher than for the average projects in your organisation?</td>
<td>NUMSOC</td>
</tr>
<tr>
<td></td>
<td>Would you say the diversity of stakeholders involved is higher than for the average projects in your organisation?</td>
<td>DIVSOC</td>
</tr>
<tr>
<td></td>
<td>Is the communication due to the amount or diversity of stakeholders difficult?</td>
<td>COMPLCOMM</td>
</tr>
<tr>
<td></td>
<td>Are goals uncertain due to the amount or diversity of stakeholders difficult?</td>
<td>UNCERGOAL</td>
</tr>
<tr>
<td>Technical complexity</td>
<td>Would you say that the number and interaction of technical components in higher than for the average projects in your organisation?</td>
<td>NUMTEC</td>
</tr>
<tr>
<td></td>
<td>Is the communication due to the amount of technological components difficult?</td>
<td>COMPLCOMM</td>
</tr>
<tr>
<td>Knowledge Complexity</td>
<td>Do you relatively have a lot of knowledge to be discovered at start?</td>
<td>KNOWLEDGEST</td>
</tr>
<tr>
<td></td>
<td>Are goals uncertain due to the lack of knowledge at start?</td>
<td>UNCERGOAL</td>
</tr>
<tr>
<td>Social Volatility</td>
<td>Are stakeholders or requirements expected to change before delivery?</td>
<td>CHANGESOC</td>
</tr>
<tr>
<td></td>
<td>Do you face time criticality of goals due to changing conditions of in the organisation?</td>
<td>URGENCY</td>
</tr>
<tr>
<td>Technical Volatility</td>
<td>Are technical components expected to change or become obsolete before delivery?</td>
<td>CHANGETEC</td>
</tr>
<tr>
<td></td>
<td>Are you dealing with very new technology?</td>
<td>NOVELTEC</td>
</tr>
<tr>
<td></td>
<td>Do you face time criticality of goals due to changing conditions of in the technology?</td>
<td>URGENCY</td>
</tr>
<tr>
<td>Knowledge Volatility</td>
<td>Are regulations or environmental conditions expected to change before delivery?</td>
<td>CHANGEENV</td>
</tr>
<tr>
<td></td>
<td>Do you face time criticality of goals due to changing conditions of in the environment?</td>
<td>URGENCY</td>
</tr>
</tbody>
</table>

Table 7.3: Mapping between dimensions, questions and factors used as input during practitioner evaluation to identify characteristics of complexity and volatility.
7.2.1.4 Description of the procedure

As preparation for the interviews, participants were asked to choose a recent complex and/or volatile project from their own professional practice and reflect about which project management practices were applied to the project and with which results (please see Appendix D, Section D.1.1 for more detailed information).

The interviews were structured as follows:

1. Each participant was requested to describe the project they had chosen. Documentation about problem, project, applied controls, rationale and project outcome were collected as notes during the interview.

2. The characteristics of complexity and volatility were identified using the questions shown in Table 7.3.

3. The participant was offered the list of recommended controls in the organisational problem space and in the project problem space. Each was then explained to the participants in detail, using the description provided by the tool, as shown in Figure 7.18.

4. The participants were asked to assess the suggestions in comparison to their recalled experience.

5. The participants were then asked to fill in a post-interview survey (see Appendix D, Section D.1.3), to evaluate these suggestions commenting on:
   - the relevance of the questions used as input;
   - the extent the recommendations were suitable to the chosen project; and
   - the applicability of a method that gave such recommendations.

The instructions displayed to the participants together with the steps captured from the tool are described in detail in Appendix D, Section D.1.2.2.

7.2.2 Summary of findings

In this section I summarise the findings of the seven interviews.
7.2.2.1 Interviewees’ experience

As required for participating in the interviews, all respondents had more than 5 years’ experience as project managers (6 out of 7 had over 10 years’ experience). Four of them were currently working as project managers, one was working as a project team member, and the last two were working as program and portfolio managers. During the last three years they managed mostly administrative and product and service development projects (70% of the projects). A summary can be seen in Figure 7.19.

![Figure 7.19: Summary of respondents’ experience](image)

7.2.2.2 Comments on the applicability of the method

**Applicability of the method during project life cycle** 6 out of 7 participants described the method as helpful. Respondent 1 commented:

> it is intuitive; sitting at the beginning of the project and being able to work through systematically is helpful.
Respondent 2 also commented:

> it is useful as a way of thinking through risk, especially at the initial stages of the project. It gives opportunity to think a bit clearer about possible changes as the project develops.

Respondent 7 noted that the method is:

> more apt at program level than at project level, to be used when defining the business case, to support project plans or at resource requests.

**Using the method recommendation as support for communication**  All respondents saw the method as a way of explaining to other stakeholders why a certain approach was chosen. Respondent 1, for instance, commented:

> the suggestions can be shared with other people and explain why you used an approach, especially if people are not PMs.

Respondent 7 also commented that the method was a way to communicate decisions to stakeholders:

> it provides evidence to support an argument.

Respondent 5 mentioned:

> tool useful to getting the buy-in from stakeholders, potentially it could be a useful thing in large organisations.

Respondent 6, however, noted that:

> It seemed quite complex to use such a tool, less information should be input with a clear output; the output should be more straight-forward; a system should be clearer. People want information better presented than in an Excel sheet.

**Identified limitations**  Some participants identified limitations to the applicability of the method. Respondent 3 commented:
there is value behind it, but the language is not always understandable, may be because of the formal approach. Some things may not be relevant (...) because of the type of project and type of project managers.

Respondent 5 commented:

it is not always useful in the wild west (software projects) or in very small companies.

7.2.2.3 Comment on the relevance of the questions used as input

Questions relevant to support decision making process The questions used as input were considered relevant in supporting and giving structure to the decision making process, as stated by Respondent 1:

decision is supported by the questions, which help to identify things that are important; it is a guided process

and also mentioned by Respondent 2:

for new PMs would be useful, it is a sort of aide memoir or as a help not to forget.

Questions need to be adapted Questions should be adapted to the organisational characteristics, as commented by Respondent 3:

the challenge is that the questions need to be considered within the context of the organisation

and also mentioned by Respondent 7:

some of the terminology should be adapted to the project environment, needs a better thinking.

Closed questions Respondents 4 and 6 had difficulties to answer the questions with ‘yes’ or ‘no’ as noted by Respondent 6:

questions were relevant, but did not offer any middle ground; for some of the questions, a scale would have been better than yes or no.
7.2.2.4 Comment on the recommendations provided by the method

Quality of the recommendations In all cases, the proposed controls matched the PM’s expectations and the method gave them an insight into how to manage risk, as suggested by Respondent 4:

the recommendations were very relevant; it gave choices, I like to know the alternatives and then make the judgement; information was realistic. They were good choices, all of them were accurate, you could see the pattern.

The method also appeared to challenge respondents, as stated by Respondent 1:

to a great extent, it was also good to see other possible controls and to be confident that other options are not suitable and challenge the PM to go out of their comfort zone.

Additional information displayed Furthermore, the linkage to the related PMI PM processes was perceived as an advantage, as mentioned by Respondent 1:

PMI PM processes are important, because they help to know how project managers can actually do it.

Suggestions to improve controls However, there were some issues in the way controls were described. For instance, participant 5 found that more explanation was needed, while Respondent 2 stated that

a key element missing are roles and responsibilities

and Respondent 6 mentioned that

some of the recommendations were suitable, but not all were always possible.

7.2.3 Analysis of findings

If results of the practitioner evaluation are added to those obtained through the case study evaluation, they provide insight in relation to the applicability of the method.
Overall, respondents appear to recognise that there is value in applying the method, especially at program level and at earlier stages of the project life cycle, for instance, when defining the business case.

There were also clear limitations of the method in terms of its applicability for smaller organisations or certain project types. Even the organisational culture plays an important role in terms of which controls are possible or effective. Adding controls that are culture or project type specific, or developing specific questions bespoke to the type of organisation or type of project, could be useful to overcome these limitations.

PMs perceived the method as complementing to their expert judgement. Interestingly, they saw in the application of the method a means to improve communication with relevant stakeholders, as it provides explicit independent rationale to support decision making.

Although not included in the evaluation, the tool introduced some usability issues, either because of the way the information was presented or because of restricting the input to yes or no answers. This was useful feedback, given we hope to develop software based on the method.

7.3 Discussion

Alignment with practice  Based on the findings, the recommended controls align with practice in the way they are used to mitigate risk. This was expected as most of the suggested controls to mitigate risk derive from the literature review and expert judgement. That this was transparent through the method suggest alignment with practice is a feature of the method. Additions to practice were the justifications for choices, which were seen as helpful.

Applicability  The results of the practitioners evaluation give an indication in relation to the applicability of the method by project managers.

We evaluated both how difficult it was for practitioners to apply the method together with the relevance of the questions used as input, and how proposed controls align with current practice.
However, the evaluation was not detailed enough to observe how different people would have addressed problem solving differently, for example in the case of problem decomposition. This was expected as a corollary of the choice of model 2 above.

Although the respondents were guided through the application of the method, the tool used for the evaluation raised various usability issues, confirming that the careful development of software to apply the method would be beneficial.

As also confirmed by the respondents, the application of the method complements current project management practices. However, the practitioner evaluation gives an indication that the way the controls are described could be an issue for certain PMs.

Results from both the application of the method to the case study and from the practitioners evaluation do not contradict the hypothesis that the method proposes suitable adaptive and predictive controls based on problem characteristics of complexity and volatility, which can be combined systematically into hybrid approaches to manage the resulting risk. Of course, further active evaluation will be necessary to confirm my hypothesis but this may take many years.

Further engagement of practitioners in the evaluation of the method, together with its application in new projects is necessary to understand how the framework could be enriched and, additionally, to give the possibility to assess any practical benefits.

Extending the method Practitioners indicated that contextualisation of the method would be helpful. In addition to the preexisting sets of controls, new controls can also be added to the method if they might be needed for a particular organisation or industry sector. In order to do so, a control should be classified and included in the corresponding tables (Figures 6.2, 6.3 and 6.4), i.e. once the new control is duly characterised, it can be considered in the selection of the recommended controls. This extension was not tested.

The method can also by extended by the consideration of additional problem characteristics as source of risk. Examples include ambiguity and uncertainty, often seen alongside complexity and volatility (Bennett and Lemoine, 2014). In this case, further research will be needed to identify both the factors driving risk and the suitable controls.
Chapter 7. Evaluation

7.4 Summary

The goal of this chapter was to provide some validation of the ideas developed in the dissertation, including both the POE interpretation of PM concepts from Chapter 4 and the PM parametrisation method from Chapter 6.

Through the application of the method in the case study, I observed how the initial exploration of organisational problem steps can help uncover risk, while the application of risk controls based on the revealed risk characteristics resulted in hybrid project practices which were not result of a specific project methodology but on the need to mitigate risk.

Revisiting the research question:

Q1: How can PM concepts be interpreted in POE?

I can say that the case study has contributed to validate the ideas introduced in Section 4.2 as the problem oriented interpretation of projects was successfully applied to a complex and volatile problem, showing POE concepts could be used to capture key elements of the project and thus support risk identification.

In relation to research question:

Q3: How can PM processes be parametrised based on problem characteristics?

I can say that the case study further contributed to the positive evaluation of the designed method: the application of the same method in a different case study in a different organisation has contributed to increase the validity of this research.

As mentioned in Chapter 3, this research has followed an interpretative paradigm, where the researcher’s own assumptions, knowledge and experience have shaped the research process. Although this case study comes from the author’s professional practice, objectivity and reliability was ensured by documenting all the research procedures applied. Moreover, the role of the author as a member of the project steering committee granted access to detailed project information. Objectivity was reinforced by the fact that the project itself was managed by a different project manager.
Moreover, the evaluation by practitioners, where the method was applied retrospectively to real-life organisational problems from their practice, has added validity to this evaluation, as the method was tested beyond the author’s interpretation.

In conclusion, case studies and practitioner evaluation together have validated to a reasonable extent the method.
Chapter 8

Discussion and conclusion

This chapter concludes the dissertation. In Section 8.1 I review to which extent the research questions have been answered, including a discussion of both theoretical and practical benefits of the research and threats to validity. In Section 8.2 I discuss future work.

8.1 Critical evaluation against research questions

The aim of this dissertation was to investigate the relation between organisational problem characteristics and the parametrisation of PM practices and to analyse how an existing problem solving approach, the Problem Oriented Engineering (POE) framework can guide this parametrisation.

In order to answer the research questions I formulated, I adopted a mixed method approach.

8.1.1 Q1: How can PM concepts be interpreted in POE?

To address this question, primary research was conducted in form of a case study from the author’s professional practice, supported by a review of related academic literature, which has highlighted the view of complex project management as complex problem solving (Ahern, Leavy, and Byrne, 2014).

In Chapter 4 I introduced an interpretation of PM as problem solving within POE, and how POE concepts can be used to capture PM processes and practices, as well as complexity and volatility characteristics of problems.
In Chapters 4 and 7, by means of case studies, I demonstrated how POE problems and transformations can be used to capture how projects progress, with POE design trees providing a rich and detailed project representation, including the project life cycle and phases, the rationale behind each process step, and where and why process backtracking occurs when things go wrong.

The differentiation between organisational and project problems I have introduced has allowed me to separate problem and solution spaces and investigate how the two spaces interact. The ‘starting the project phase’, where solution exploration cycles refer back to the problem space, or the ‘quality gates’, where both problem and solution owners validate the project deliverables, are the key bridges between the organisational problem and the project as a problem solving activity.

Problem diagrams, used in POE but defined in Jackson (2001), and the sharing of phenomena were shown to be effective tools to reveal complexity, helping to provide plausible explanations of why in the case studies some of the project steps failed while others succeeded.

This novel application of POE to PM practices is not only a contribution to knowledge but to practice as well. I could see in the case studies how insufficient understanding about the problems that the projects were set up to solve but failed to do so was a source of waste. In reverse, sufficient understanding about the problem might be useful to avoid waste.

8.1.2 Q2: which factors affect current choices of PM approaches made by practitioners in organisations?

Our literature review in Chapter 2 revealed how complexity and volatility are key characteristics of today’s organisational problems. Their importance in projects is due to the fact that they are sources of risk which threaten project success (Fafinski, 2008). However, I could not find clear and universal definitions of complexity and volatility in the literature, so that in my research I synthesised definitions of complexity and volatility. Specifically, I have defined complexity as related to the presence of many interconnected parts, and volatility as related to the likelihood of rapid change, each manifesting itself
along the following dimensions: social, when related to people; technical, when related to technologies; and knowledge, when related to what is known.

The literature reviewed indicated that in order to take appropriate PM decisions, practitioners must be able to assess the level of complexity and volatility they are dealing with (Remington, Zolin, and Turner, 2009). In Chapter 2, I was able to identify from the literature specific observable factors which are sources or manifestations of complexity and volatility, and how such factors give rise to specific project risk which requires mitigation during a project life cycle or assigned problem solving activity (Tiwana and Keil, 2004; Baccarini, 1996).

The literature review also highlighted how the different PM methodologies deal with such risk differently: while predictive methodologies focus on dealing effectively with complexity and controlling volatility, adaptive methodologies embrace volatility and adaptation to change (Boehm and Turner, 2004), with neither of them being a perfect match for today’s organisational problems, so that hybrid approaches are on the rise (Theocharis et al., 2015).

However, I could not find in the literature a clear understanding of how complexity and volatility factors are used to parametrise PM processes in practice, or what the mechanics of hybridisation of PM methodologies are. Such knowledge gaps were therefore addressed by my primary research.

In Chapter 5 I investigated how practitioners look at complexity and volatility factors to parametrise their PM processes, which often results in ad-hoc hybrid approaches.

By breaking down complexity and volatility into their prevalent dimensions and manifestations, and PM methodologies into their constituent controls, I was able to investigate a finer-grain mapping between specific risk factors and methodological controls, both from a theoretical standpoint and in conversation with practitioners, via a survey and subsequent interviews. As a result, I could start to attribute specific factors to specific project practices and hybridisation, but also clarify some apparently contradictory results with practitioners, for instance, their preference of predictive controls to mitigate social volatility could be understood as the wish to ‘control’ the changes. I could also observe to which extent practitioners’ experience and personal preferences affect their approach to risk control: while some project managers would rely on strict predictive
controls even to deal with volatility, others would rely exclusively on team expertise or agile methodologies to deal with both complexity and volatility. The heterogeneity of the respondents’ preferences contributed to enrich my mapping, although some limitations remain partially due to the level of subjective interpretation which was required in its synthesis, and the relative small sample of practitioners (n=31) who have taken part in the study. However, triangulation with secondary evidence collected in the literature provided some mitigation against the latter.

8.1.3 Q3: How can PM processes be parametrised based on problem characteristics?

In Chapter 6 I proposed my novel method to parametrise projects systematically in the face of complexity and volatility, developed both from my POE interpretation of projects and PM as problem solving and from my mapping between risks and controls.

In defining the method, POE elements, such as problem decomposition or stakeholder substitution, were identified as risk controls, so to extend my mapping to the (organisational) problem space alongside the (project) solution space.

The proposed method supports systematic project hybridisation based on problem characteristics. To that extent, single elements of the PM methodologies, which I define as controls, were isolated according to the risk they intend to mitigate. These controls were obtained by combining the knowledge obtained from the literature, the findings of the primary research conducted in Chapter 5 and the retrospective case study in Chapter 4.

My method is made up of methodical instructions to collect candidate controls which are refined through the steps to a minimum while ensuring that the risk is controlled.

It consists of an interplay between specific risk factors and methodological controls that systematises hybrid practices. It contradicts received wisdom that complexity can only be managed through predictive methodologies and volatility through adaptive methodologies. Moreover, it differentiates from other approaches to hybridisation found in the literature (Section 2.4.2), where:
• either adaptive parts of the project are encapsulated within a general predictive approach followed for the rest, as in ‘Water-Scrum-Fall’ (West et al., 2011; Theocharis et al., 2015)

• or predictive elements are introduced to adaptive methodologies to support the complete life cycle and enable scaling, as in DAD (Ambler and Lines, 2012).

The steps to applied the designed method are listed in Table 8.1

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Problem exploration</td>
<td>in which I explore the problem in order to gain understanding about the need and context, identify shared any phenomena and tangling, and reveal a problem’s characteristics of complexity and volatility, usually through the application of control 6*</td>
</tr>
<tr>
<td>2. Choice of candidate controls</td>
<td>I consider the controls with strong mitigation (G) against the identified dimensions of complexity and volatility. Recall that in the case I am in the organisational problem space, I consider only the starred controls (*). The result is a collection of candidate controls to work with.</td>
</tr>
<tr>
<td>3. Mutual exclusion</td>
<td>I check for mutual exclusion between chosen controls. This reduces the choice to non-mutually exclusive collection of controls.</td>
</tr>
<tr>
<td>4. Prioritisation</td>
<td>focuses on the controls which are more likely to successfully mitigate risk based on the characteristics of the problem. This will be achieved by considering the control objectives related to the candidate controls.</td>
</tr>
<tr>
<td>5. Cross effect</td>
<td>I check if the selected controls have an effect on the mitigation of risk derived from other dimensions. This can reduce the collection of controls by merging those whose effect I duplicated.</td>
</tr>
<tr>
<td>6. Impact</td>
<td>I evaluate the impact of the choice of controls in terms of budget, scope and schedule. This further reduces the collection of candidate controls.</td>
</tr>
<tr>
<td>7. Feasibility of the choice</td>
<td>I consider any additional information that might affect the choice of a specific control, as the phase where it is applicable (e.g. control 4, only applicable in ‘starting the project’), or the content of the field constraints (e.g. control 4 ‘not possible if volatility’).</td>
</tr>
</tbody>
</table>

**Table 8.1:** Steps to collect and refine candidate controls

Real-world case studies were used to both exemplify (Chapter 6) and evaluate (Chapter 7) the method. In both cases, the application of the method provided objective decision paths to choose risk controls and to give feasible explanations of the real-life project
outcomes in relation to the way risk was mitigated. The additional evaluation with practitioners has confirmed that the method has the potential to become a systematic approach to help project managers calibrate their project methodologies and practices based on problem characteristics, intended to reduce the related risk.

It is worth noting that the proposed method also exhibits some of the characteristics which had emerged as desirable requirements in the practitioners’ interviews presented in Chapter 5. Specifically:

- How to break down work packages effectively and eliminate peaks by fine-tuning iterations: controls 15* and 15 (problem and project decomposition) are related to this requirement. To that respect, I should note that the way in which the decomposition has to take place is not within the scope of my method. However, POE has a concept of separable problems and solution architectures which can be used to guide decomposition. An application of this concept to the domain of project management can be part of future research.

- How to estimate the effort needed to manage communication and alignment with stakeholder: I observe that, as support of the choice of controls, my method provides an indication of the impact of each control on budget, scope and schedule so as to estimate in beforehand their effect on project performance. Moreover, the fact that the procedure is based on a method makes it easier for others to understand the rationale behind the application of controls and project architecture, and thus improves the management of stakeholders.

- How to decide when being agile is an option or a must: I can say that my method does not recommend a specific project methodology, but specific individual predictive or adaptive risk controls based on contextual factors which may result in predictive, hybrid or adaptive project architectures.

8.1.4 Limitations and threats to validity

It is important to remark that while there are several available PM standards and guidelines from professional bodies, such as PRINCE2 (Government Commerce, 2009), ICB (International Project Management Association and others, 2006) or the ISO norm 21500
(Stellingwerf and Zandhuis, 2013), this work aligns with the PMI standards compiled in the PM Body of Knowledge (PMBOK) (Project Management Institute, 2017a), and no attempt has been made to map it towards those other standards.

Moreover, the proposed framework is based on the premise that both the generic project life cycle and the PMBOK process groups can be tailored to fit adaptive approaches, in concordance with the approach described in (Project Management Institute, 2017a).

The evaluation of my proposed method was conducted via a case study in Chapter 7 followed by a practitioner evaluation. The fact that the method was being assessed for commercialisation by The Open University restricted the possibility to try the method with PMs working for other organisations. However, the interviewees worked in different parts of the organisation and the projects taken as reference to apply the method were of a different nature.

Moreover, my participation in practitioners’ conferences over the duration of the research, where the work was presented and discussed, has allowed a partial validation of the relevance of some of the aspects of this research to professional practice. For instance, after my presentation at the DSAG-Globalization-Symposium 2016 in Berlin, I was approached by several practitioners in relation to the importance of a methodology to structure the project front-end. This gave me the motivation to proceed developing this aspect of the research. Further presentations, such as the PM Congress 2019 in Delft and the STPIS 2020, supported the recognition of complexity and volatility as sources of risk, corroborating the choice of these problem characteristics as input for my method.

In line with the interpretative paradigm followed by this research, external validity was addressed by the application of the method to different case studies from different organisations, while internal validity was addressed through careful documentation of all the research procedures applied, so as to make it possible to carry out an audit trail.

As explained in Chapter 3, a direct evaluation of to which extent the method would effectively control risk could not take place due to the inability to establish the necessary research conditions for an experiment to observe the direct effects of the controls chosen by the method in a real-life project.
8.1.5 Personal reflection on the research

My initial motivation to start this research was to gain a better understanding of why projects fail or succeed. Early on in the process, I focused on the importance of the ‘starting the project’ phase and the right choice of ‘concept’, that is a candidate solution to be delivered by the project. Later on, the understanding of a project as a problem solving activity changed the focus of my research towards considering the characteristics of the problem to be solved, which could influence decisions along the project life cycle. I did not think that existing project management methodologies were addressing this, either because they were too prescriptive, such as SCRUM, for instance, or too loose, such as the PMBOK, which describes all dimensions of projects and project management processes, but does not provide guidance on what to do.

From then on, I set my focus on complexity and volatility and their related risks. Looking at complexity and volatility from a risk perspective showed that each of their dimensions gives rise to different types of risk which manifest differently. Risk mitigation, either by reducing the likelihood of occurrence of an adverse event or by reducing the impact, became the lens I used to assess PM methodologies in relation to the way they control risk. This interpretation together with the understanding of the risk factors I found in the literature, allowed me to develop the fine grain mapping between problem characteristics that generate risk and their corresponding controls.

Practitioners’ input in relation to the mapping was not always as I expected. Particularly, the way that project managers tend to use their experience and beliefs when setting up projects makes their individual responses rather subjective. However, examining all received responses as a whole, together with the rationale behind them, helped me enrich and increase the validity of the mapping, as many different point of views were considered.

Finally, the results of this research exceeded my expectations as a practitioner. I originally expected a recommendation of measures to mitigate risk in projects. In the end, I developed a method which helps to apply different types of controls from either predictive or adaptive paradigm in an hybrid fashion.

Closing the cycle that started many years ago, as a practitioner, I feel I am now in a better position to not only understand why a project may fail or succeed, but also to
actively contribute towards project success through a systematic approach to risk mitigation. Firstly, analysing the project from a problem-oriented project perspective helps me understand the contextual characteristics of the project and act upon them in an appropriate manner. Following the developed method, the regular and systematic evaluation of risks and how to control them throughout the project allows me to both parametrise the project correctly from the starting phase, and to identify changes and adapt accordingly, as the project proceeds.

Moreover, the application of the extra (POE-based) controls applicable in the organisational problem space gives me a broader perspective, because they augment organisational problem solving beyond projects, as not all organisational problems are solved by projects.

8.2 Future research

There are many opportunities for future research, especially in relation to the practical application of the proposed method in the field of PM, where a first next step would be its application to live projects. Although the method was further validated by the practitioner evaluation, a live project would additionally give an opportunity to quantify its impact in terms of risk reduction, possibly based on a comparison with similar projects where the method is not applied.

As confirmed by the practitioner evaluation, the experience gained in the further application of the method would give the opportunity to a) extend, b) improve and c) specialise the method.

a) In relation to the extension of the method, I could identify new controls or fine tune those already included with respect to the level of mitigation they provide against any dimension of complexity and volatility. Similarly, other problem characteristics or factors which are a source of risk may be considered and included in the method. Ambiguity and Uncertainty, as explained in Chapter 7, could be the next characteristics to look at as part of future work.

b) In relation to the improvement of the method, the further application of the method
in case studies may lead to the identification of patterns in relation to the problem structure. Similar types of problems might have similar problem solving processes, meaning that templates of the problem structure could be developed to be used as a reference when doing a problem oriented characterisation. This will not only simplify to some extent the application of the method but also help reducing the likelihood of mistakes.

As also suggested during the practitioner evaluation, another improvement to the method would be the development of a software tool to guide the users through the method steps, reduce the incidence of human errors and generally make the method more accessible to end users.

This tool could also be combined with existing PM software applications, such as MS Project, for better integration with follow-up project work and task assignment.

c) In relation of the specialisation of the method, both, the inclusion of specific context-derived, culturally-derived or personal preference and expertise derived controls, together with the consideration of additional problem characteristics as source of risk could be a way to tailor the method to an specific organisation or to a specific industry sector based on their culture, preferences or context.

### 8.2.1 Quantifying complexity and volatility

In both, case studies (Chapters 6 and 7) and practitioner evaluation (Chapter 7), complexity and volatility were recognised and represented, but no numerical quantification was done. Future research could be done in this respect.

It is important to remark that the assessment of complexity and volatility is industry specific, therefore, based on the observation of real projects, specific indicators for different types of industry could be developed as part of the future work.

I now sketch some ideas on how quantification of complexity and volatility could be achieved.

#### 8.2.1.1 Measuring complexity

Quantifying complexity is about counting. Meaning that the number of social, technical and knowledge components needs to be determined. Similarly, the number of interactions within the components and between the components needs to be considered. For
instance, in case of dealing with socio-technical systems, not only the interactions between people or between machines are relevant, but also the interaction between people and machines need to be considered. The same applies to socio-knowledge or techno-knowledge interactions. It is important to remark that while the number of components increases in a linear fashion, the number of interactions increases exponentially. For instance, when a new stakeholder needs to validate a problem, the measurement of the social complexity will not only be influenced by one additional component, but also by the number of the interactions between the new stakeholder and the rest of stakeholders.

Function points is a model for estimations proposed by Albrecht and Gaffney (1983) which counts the number of complexity of technical components to estimate the size and effort required for an IT system (Karner, 1993). Part of future work would be to look at the literature to validate to which extent the model is applicable to quantify complexity in the domain of organisational problems.

8.2.1.2 Measuring volatility

Measuring volatility is about measuring the rate of change of the social, technical and knowledge components. Although not mentioned so far in the thesis, the drift model (Costantini, Hall, and Rapanotti, 2017) offers some hope that the rate of change can be measured and thus help to measure volatility.

The problem drift model, illustrated in Figure 8.1, was developed to explicate the relation between volatility and the PPP.

---

**Figure 8.1:** Problem drift model
I define *problem drift* as the rate at which the context, need or solution of a problem change, say because a customer reevaluates their need, the technologies on which a solution will be based are evolving quickly, or because an organisation’s context is evolving. A problem with high drift rate will change quickly, that with a low drift rate will change slowly. In the diagram,

- the vertical axis represents *problem drift*, which is a measure of divergence from the problem the project was set up to solve and that which is in the real world, as a result of problem volatility;

- the horizontal axis represents resource use (equivalently, the passage of time) from most recent validation (initially output from starting the project phase);

- I assume an *acceptable drift range* (the shaded area), where the divergence is not sufficient to invalidate development of the solution. Note that this is stakeholder dependent;

- *the drift rate* lines indicate the degree of problem volatility: from high (V1), i.e., the environment changes very quickly, to low (V3), where it changes more slowly.

Marked on the horizontal axis is a *validation point*, which is the point where validation from a stakeholder on some problem solving artefact is sought. Three situations are considered: i) in a situation of low drift (V3), drift has occurred but is not sufficient to affect stakeholders’ validation; ii) when medium drift (V2), drift leads to a marginal call on the boundary between acceptable and unacceptable drift; iii) when high drift (V1), the validation artefact cannot be validated as drift has affected the stakeholders’ judgement and some or all development resource is lost.

The drift model explains why iteration is needed in projects in the presence of problem volatility. At the extremes:

- when problem drift is extremely low, even long period plan-driven methods would require validation only at project end as accumulated problem drift is insufficient to invalidate the project’s outputs.

- when problem drift is higher, validation must occur more often so that excessive drift is never experienced.
This must be balanced, of course, there is a trade-off between the cost of the validations and risk of losing resources for advancing in a solution without validation that is a function of the volatility of the problem.

Drift metrics As it stands, the drift model has no metrics associated with it. To remedy this, I propose that, early in problem solving, stakeholders are asked to validate prematurely so that either high drift rates situations are brought to light early or low drift rates can be identified.

The success or failure of the iteration with stakeholders at the validation points (i.e. if you are within the acceptable drift region or not) will give an indication of the rate of change and thus can be used to measure volatility.

Given the above procedure, the length of the iterations can be estimated.
Appendix A

Case study: Master data implementation problem

A.1 Description of the Organisational Project steps

Organisational Problem step 1: First identified solution  The first solution identified was Reproduce initial solution and pay a fee to company B.

In Figure 4.15 we can see the corresponding description of the problem and proposed solution domains by means of problem diagrams.

Organisational Problem Step 2: Second identified solution  After rejecting the first solution, the designated project manager organised a workshop with the relevant headquarter stakeholders. During this workshop, another solution was identified. It consisted of the implementation of a harmonised and centralised partner data creation application, where the subsidiaries could initiate the partner data creation and the data would be replicated in the subsidiaries ERP systems after an automatic validation.

Following the example mentioned above, when a new customer record needed to be created, the data would be directly introduced in a new application following the application’s data structure, validated according to the internal system rules and then re transmitted to the subsidiary’s ERP. This would force the data structure to be harmonised between all systems. Other subsidiaries entering customers, for instance, would need to share the structure too.
This solution had some additional benefits for company A, such as the global visibility of partner data while the data to be transferred needed to be harmonised to reduce complexity in the central master data application.

In Figure 4.16, we can see the corresponding diagrams representing the domains and phenomena corresponding to the problem and solution as implemented in P2. In Figure 4.17, we can see a detailed representation of the domains and phenomena corresponding to the problem and solution as implemented in P2 after a solution interpretation and in Figure 4.18 we can see again the representation of domain and phenomena corresponding to the problem and solution as implemented in P2, on greater detail after the context and solution interpretation.

Organisational Problem step 3: Third identified solution  

After considering the requirements from the subsidiaries, a third solution was identified and after a very short analysis, discarded. It aimed at reducing the changes in the subsidiaries’ ERPs using a data converter. This data converter would adapt the partner data records generated centrally, converting them into formats that could be processed by the local domains by means of translation tables.

In Figures A.1 and A.2, we can see the corresponding diagrams representing the domains and phenomena corresponding to the problem and solution as rejected in P3.
Organisational Problem step 4: Implemented solution  The implemented solution was an adaptation of the solution in step 2. It was based on a review of the needs and on a negotiation between the stakeholders in headquarters and subsidiaries. This solution was finally accepted because of the following reasons:

1. The board’s objective of validating data was fulfilled.
2. Data transparency was achieved by the central application.
3. Local domains needed to change slightly to accommodate to the central configuration only for data requiring validation, and this change was accepted by the subsidiaries.
4. The maintenance of the configuration did not generate high risks, because of the central data maintenance. This means that if the configuration was not changed centrally, data could not be entered using this new configuration, thus the subsidiaries would take care to inform headquarters about changes accordingly.

In Figures A.3 and A.4 we can see the corresponding diagrams representing the domains and phenomena corresponding to the problem and solution as rejected in P2.
Appendix A. Case study: Master data implementation problem

1.1 Table describing the problem steps

**Domain** | **Domain description** | **Phenomenon** | **Phenomenon description**
--- | --- | --- | ---
Company A (CA) | Parent company, owner subsidiary X and Y | | |
Subsidiary X (SX) | Child company belonging to CA | | |
Subsidiary Y (SY) | Child company belonging to CA | | |
Master data governance (MDG) | Policies and processes for data governance and quality assurance | | |
Master data application (MDA) | Application that supports the implementation of master data record in ERP X and Y | | |
Configured master data record (CMRD) | Configured master data record in ERP X and Y | | |
Configured applications (CA) | Applications that support the implementation of master data record in ERP X and Y | | |
Transactions in ERP X (TX) | Transactions in ERP X that require master data record and support SX processes | | |
Transactions in ERP Y (TY) | Transactions in ERP Y that require master data record and support SY processes | | |

**FIGURE A.3:** Final solution - POE Diagram

**FIGURE A.4:** Final solution - Domain and phenomena descriptions
## Appendix A. Case study: Master data implementation problem

### Master data implementation problem

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Phase (project problems only)</th>
<th>Status (Problem validation)</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status Solution</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td></td>
<td>v</td>
<td>Board</td>
<td></td>
<td>P1</td>
<td>Need and context interpretation lead to P1</td>
<td>Keep same compliance level as provided by the initial solution while minimising costs</td>
<td>Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>n/a</td>
</tr>
<tr>
<td>P1</td>
<td></td>
<td>v</td>
<td>Board</td>
<td>N1: to be able to validate partner master data</td>
<td>Company A</td>
<td>Board did not approve to continue with the alternative due to the fees</td>
<td></td>
<td>BoardX</td>
<td>Buy services from company B</td>
</tr>
<tr>
<td>PP1</td>
<td>Starting</td>
<td>v</td>
<td>Board</td>
<td>Explore feasibility to continue with current solution provided by company B and pay fees for the service</td>
<td>CMD B, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y, Fees, Company B</td>
<td>v</td>
<td>Board</td>
<td>Feasibility explored</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td></td>
<td>v</td>
<td>Board</td>
<td>N1 &amp; N2: achieve data transparency</td>
<td>Company A</td>
<td>N2 Stakeholder affected by the solution did not validate it</td>
<td></td>
<td>Stakeholder affected by the solution (Subsidiaries)X</td>
<td>to build own central system, with harmonisation of data and processes across all subsidiaries</td>
</tr>
<tr>
<td>PP2</td>
<td>Starting</td>
<td>v</td>
<td>Board</td>
<td>Explore feasibility to use MDG A to process, approve and validate partner master data records and then transmit them to ERP X and ERP Y for further use in transactions</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Budget holder, IT architect</td>
<td>Approval to set up the project to implement MDG A</td>
<td></td>
</tr>
<tr>
<td>PP2.1</td>
<td>Organising and preparing</td>
<td>v</td>
<td>Project manager</td>
<td>Organise and prepare activities necessary to implement MDG A</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Stakeholder providing resources</td>
<td>Project plan for the implementation of MDG A</td>
<td></td>
</tr>
<tr>
<td>PP2.2</td>
<td>Carrying out the work</td>
<td>v</td>
<td>Project manager, project team, vendors</td>
<td>Carry-out project work to implement MDG A</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Project manager, project team, vendors</td>
<td>MDG A implemented</td>
<td></td>
</tr>
<tr>
<td>PP2.3</td>
<td>Carrying out the work</td>
<td>v</td>
<td>Project manager, project team, vendors</td>
<td>Test MDG A</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Stakeholder affected by the solution (Subsidiaries)</td>
<td>Testing could be successfully executed with negative results as the stakeholder affected by the solution did not accept it</td>
<td></td>
</tr>
</tbody>
</table>

**Figure A.5: Problem steps 1/2**
### Master data implementation problem

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Phase (project problems only)</th>
<th>Status Problem validation</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status Solution validation</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3</td>
<td></td>
<td>v Board</td>
<td>N1 &amp; N2 &amp; N3, with N3: no changes to subsidiaries' systems</td>
<td>Company A</td>
<td>IT architect rejected the solution due to the high effort to implement and maintain the translation tables.</td>
<td>X</td>
<td>IT architect X</td>
<td>to build own central system, with harmonisation of data and processes and with data converter to subsidiaries' local configurations</td>
<td></td>
</tr>
<tr>
<td>PP3</td>
<td>Steering</td>
<td>v Board</td>
<td>Find a technical solution to adapt MDG A so that to reduce impact in the current subsidiaries’ processes</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y, converter, translation tables, ERP X, ERP Y</td>
<td>v</td>
<td>IT architect X</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td></td>
<td>v Board</td>
<td>N1 &amp; N2 &amp; N3 &amp; N4, with N4, only minor changes to subsidiaries’ systems</td>
<td>Company A</td>
<td>IT architect rejected the solution due to the high effort to implement and maintain the translation tables.</td>
<td>v</td>
<td>Board</td>
<td>to build own central system, with harmonisation of data and processes and with data converter to subsidiaries’ local configurations</td>
<td></td>
</tr>
<tr>
<td>PP4</td>
<td>Steering</td>
<td>v Board</td>
<td>Find a technical solution to adapt MDG A so that to reduce impact in the current subsidiaries’ processes</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Multiplier X, IT architect, Stakeholder affected by the solution</td>
<td>Stakeholder providing resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP4.1</td>
<td>Organising and preparing</td>
<td>v Project manager</td>
<td>Organise and prepare necessary changes in MDG A to implement the solution decided in P4</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Stakeholder affected by the solution</td>
<td>Project plan for the changes of MDG A, decision to split the carrying out the phase into PP4.2, PP4.3 and PP4.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP4.2</td>
<td>Carrying out the work</td>
<td>v Project manager, project team, vendors</td>
<td>Implementing the necessary changes in MDG A to implement the solution decided in P4</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Project manager, project team, vendors</td>
<td>Changes in MDG A implemented</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP4.3</td>
<td>Carrying out the work</td>
<td>v Project manager, project team, vendors</td>
<td>Validate deliverables</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Stakeholder affected by the solution</td>
<td>Changes in MDG A tested</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP4.4</td>
<td>Carrying out the work</td>
<td>v Project manager, project team, vendors</td>
<td>Execute activities in cut over plan in order to go live</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Stakeholder affected by the solution</td>
<td>Go live executed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP4.5</td>
<td>Closing</td>
<td>v Project manager, project team, vendors</td>
<td>Execute activities in cut over plan in order to go live</td>
<td>MDG A, Company A, subsidiary X, subsidiary Y, ERP X, ERP Y</td>
<td>v</td>
<td>Board</td>
<td>Stakeholder providing resources</td>
<td>All open activities closed, resources re-allocated to other projects or tasks, team and vendor evaluated, documentation completed</td>
<td></td>
</tr>
</tbody>
</table>

**Figure A.6: Problem steps 2/2**
Appendix B

Survey

B.1 Articles posted to attract respondents to the survey and interview

B.2 Questionnaire

Link to the online questionnaire and screenshots from the corresponding form, where the complete set of questions is displayed, follow (Figures B.4 to B.15).

B.3 Interview

Link to the online survey used to document the answers from the interviews and screenshots from the corresponding form, where the complete set of questions is displayed, follow (Figures B.16 to B.20).
Complex project management: matching organisational problems and project management methodologies

Organizations must adapt to their changing business environment to remain profitable, competitive and able to meet their strategic goals. Projects are the instruments they use to implement the necessary changes.

Increased globalization and market pressures are challenging organizations to become more flexible and explore new technologies and operational domains, so that the problems they face are of increasing complexity and volatility, which dramatically increases the risk of failure of the projects they set up to address them.

Today’s project management methodologies and practices are many and varied, from traditional or plan driven to agile, with all sort of hybrid approaches in between. They all aim at maximizing project success.

I am a research student at the Open University, UK, and I am conducting a study on how and why project managers choose and adapt their project methodology in their work.

Based on the observation that complex project management is in fact a form of complex problem solving, we want to explore the relationship between characteristics of organizational problems and of project management methodologies.

I am looking for project, program or portfolio managers from various industries, willing to share their experience by answering a short questionnaire. Please click on the link to participate.
Tailoring Project Management methodologies and practices

Published on November 13, 2018

Silvana Costantini
Leiterin IT & Digitalisierung at CPU Softwarehouse AG

In addition to my task at Webasto as Global Process Optimization Director, I am a part time research student at the Open University. I am conducting a study on how and why project managers choose and adapt their project methodology in real life.

If you are a project, program or portfolio manager and are willing to share your experience, please click on the link below to access the online questionnaire.

I am looking forward to your Input!

Special thanks to the project managers, who have already participated in the survey.

FIGURE B.2: Screenshot from the article posted in LinkedIn in November 2018

Silvana Costantini
Leiterin IT & Digitalisierung at CPU Softwarehouse AG

My research about how Project Managers choose and adapt their project methodology in real life is about to finish. I reopened the online survey for a week, to capture new feedback from the PM community. I am looking for project, program or portfolio managers, willing to share their experience by answering a short questionnaire: https://lnkd.in/eqPeB_4
Thank you very much for your input! #projectmanagement #projectmanagers #survey

FIGURE B.3: Screenshot from the article posted in LinkedIn in March 2020
Complex project management: matching organisational problems and project management methodologies

Hello,

I am a research student at the Open University, UK, and I am conducting a study on how and why project managers choose and adapt their project methodology in their work.

The objective of this research is to understand more deeply how project management methodologies are chosen and adapted in current practice, which methodologies are more suitable to deal with complexity and volatility and the extent different dimensions of complexity and volatility have an influence on this choice. This will help elicit requirements for the design of a systematic to tailor project methodologies to specific characteristics of organizational problems.

The results of the research will be part of the PhD Thesis and will additionally contribute to articles submitted for publication in relevant conferences and journals.

I am looking for project, program or portfolio managers from various industries, who have worked on complex projects over the past 3 years, and willing to share their experience by answering this short questionnaire: it consists of 13 questions in total, and should not take longer than 15 minutes to answer.

Your answers will be used for academic research purposes only, and your participation will be treated in strict confidence in accordance with the Data Protection Act 2018 (GDPR). No personal information will be collected in this questionnaire. Only in case you agree to subsequently participate in an interview, your email address be required. You won’t be identified in any research report which may be produced. The data collected by means of this questionnaire will be stored on my PC and destroyed after 3 years from completion of this research.

Figure B.4: Screenshot from the questionnaire developed and published through Google Forms - part 1
This research has been reviewed by, and received a favourable opinion, from the OU Human Research Ethics Committee - HREC reference number: 2908 (http://www.open.ac.uk/research/ethics/).

Participation in the survey is entirely voluntary and you may choose to abandon the questionnaire at any time. If you have any question about this research, please contact me at Silvana.Costantini@open.ac.uk

By filling in this questionnaire, you give consent for your answers to be processed under the terms stated above.

Thank you for your participation!
Silvana Costantini

*Required

I confirmed I have understood the terms stated above and wish to continue with this questionnaire *

☐ yes

FIGURE B.5: Screenshot from the questionnaire developed and published through Google Forms - part 2
Complex project management: matching organisational problems and project management methodologies

Your experience

1. How long have you been managing projects?
   - less than 1 year
   - 1 to 3 years
   - 3 to 5 years
   - 5 to 10 years
   - more than 10 years

2. In what country do you currently work?
   Your answer

Figure B.6: Screenshot from the questionnaire developed and published through Google Forms - part 3
3. Which of the following options best describes your current role?

- [ ] Project manager
- [ ] Program manager
- [ ] Project team member
- [ ] Consultant
- [ ] Other: __________

4. Which project management methodology(ies) do you apply in your work? (Choose all that apply)

- [ ] None
- [ ] PMBOK - Project Management Institute (PMI)
- [ ] PRINCE - Project management standard developed and issued by the British Office of Government Commerce (GOV)
- [ ] ICB - International Competence Baseline issued by the International Project Management Association (IPMA)
- [ ] ISO 10006 International Competence Baseline issued by the International Project Management Association (IPMA)
- [ ] SCRUM - SCRUM Alliance
- [ ] Other: __________

**Figure B.7:** Screenshot from the questionnaire developed and published through Google Forms - part 4
5. Which Project Management Certification do you hold? (Choose all that apply)

- None
- PMP: Project Management Professional (PMI)
- CAPM: Certified Associate in Project Management (PMI)
- CSM: Certified ScrumMaster (The Scrum Alliance)
- CompTIA Project+ certification (CompTIA)
- PRINCE2 Foundation/PRINCE2 Practitioner (ILX Group)
- CPMP: Certified Project Management Practitioner (EC-Council)
- Associate in Project Management (Global Association for Quality Management)
- MPM: Master Project Manager (American Academy of Project Management)
- PPM: Professional in Project Management (Global Association for Quality Management)
- Certified Project Director (Global Association for Quality Management)
- PMITS: Project Management in IT Security (EC-Council)
- Other: ____________________________

FIGURE B.8: Screenshot from the questionnaire developed and published through Google Forms - part 5
Complex project management: matching organisational problems and project management methodologies

6. Which of the following options best describes the main type of projects you have worked on in the past 3 years?

- Administrative/Management Projects
- Information Systems (Software) Projects
- Product and Service Development Projects
- Infrastructure or Construction Projects
- Other: ____________________________

Figure B.9: Screenshot from the questionnaire developed and published through Google Forms - part 6
7. Which of the following options best describes the size of the company(ies) those projects took place?

- Micro enterprise: fewer than 10 persons employed
- Small enterprise: 10 to 49 persons employed
- Medium-sized enterprise: 50 to 249 persons employed
- Large enterprise: 250 or more persons employed
- Other: __________

8. Which of the following options best describes the main characteristic of projects you have worked on in the past 3 years?

- Mostly complex (with many stakeholders, technologies, organisational units, etc.)
- Mostly volatile (likely to change rapidly and/or unpredictably)
- Both complex and volatile
- Neither complex nor volatile
- Other: __________

Figure B.10: Screenshot from the questionnaire developed and published through Google Forms - part 7
9. Which of the following options best describes the methodology you applied to those projects?

- Traditional project methodology (such as waterfall) with focus on detailed planning, well documented requirements and clear scope
- Agile project methodologies (such as SCRUM) with focus on adaptability to changing requirements and short delivery cycles
- Project methodologies mixing traditional and agile approaches
- Other: __________

10. If you chose a methodology mixing traditional and agile, please provide a brief description:

Your answer

**Figure B.11**: Screenshot from the questionnaire developed and published through Google Forms - part 8
Your choice of methodology

11. Among the following, please select the three main factors that motivate you to choose a traditional project (if factors are missing, please choose "other" and provide a brief description):

- Management / PMO requirement
- Large number of stakeholders or organizational units involved
- Diversity of stakeholders
- Large number of technologies or interfaces involved
- Novelty or uniqueness of the technical solution
- Rate of change in the organisation
- Rate of change in the technical solution
- Rate of change in the external environment, such as legal regulations
- Uncertainty of goals, unclear meanings or stakeholders' hidden agenda
- Complicated communication due to organizational or technical characteristics
- Lack of pre-given knowledge at project start
- Urgency
- High level of expertise in project team
- Other:

Figure B.12: Screenshot from the questionnaire developed and published through Google Forms - part 9
12. Among the following, please select the three main factors that motivate you to choose an Agile project methodology (if factors are missing, please choose "other" and provide a brief description):

- Management / PMO requirement
- Large number of stakeholders or organizational units involved
- Diversity of stakeholders
- Large number of technologies or interfaces involved
- Novelty or uniqueness of the technical solution
- Rate of change in the technical solution
- Rate of change in the external environment, such as legal regulations
- Uncertainty of goals, unclear meanings or stakeholders’ hidden agenda
- Complicated communication due to organizational or technical characteristics
- Lack of pre-given knowledge at project start
- Urgency
- High level of expertise in project team
- Other:

FIGURE B.13: Screenshot from the questionnaire developed and published through Google Forms - part 10
13. Among the following, please select the three main factors that motivate you to choose a project methodology that mixes traditional and agile approaches (if factors are missing, please choose "other" and provide a brief description):

- Management / PMO requirement
- Large number of stakeholders or organizational units involved
- Diversity of stakeholders
- Large number of technologies or interfaces involved
- Novelty or uniqueness of the technical solution
- Rate of change in the organisation
- Rate of change in the technical solution
- Rate of change in the external environment, such as legal regulations
- Uncertainty of goals, unclear meanings or stakeholders’ hidden agenda
- Complicated communication due to organizational or technical characteristics
- Lack of pre-given knowledge at project start
- Urgency
- High level of expertise in project team
- Other:

Figure B.14: Screenshot from the questionnaire developed and published through Google Forms - part 11
Complex project management: matching organisational problems and project management methodologies

Closing

Thank you for participating in the survey. I am planning to conduct some follow-up phone/Skype interviews in order to get a deeper insight on the topics addressed in this questionnaire. Interviews are expected to last for approximately 40 minutes. If you are willing to participate, please enter your email address below:

Your answer

Your email address is not mandatory, and I will only contact you to arrange the interview and give you further information about the interview process. There is no obligation for you to participate in the interview.

Back  Submit
Appendix B. Survey

Figure B.16: Screenshots from the interview developed through Google Forms - part 1
In the online questionnaire, you were asked to choose up to three main factors that motivate you to choose a traditional vs agile vs mixed project methodology. Your answers are displayed in the attached document. Why did you choose these factors in relation to traditional Project Management methodology?

Long-answer text

Why did you choose these factors in relation to Agile Project Management methodology?

Long-answer text

Why did you choose these factors in relation to mixed Project Management methodology?

Long-answer text

**Figure B.17: Screenshots from the interview developed through Google Forms - part 2**
Appendix B. Survey 221

Figure B.18: Screenshots from the interview developed through Google Forms - part 3

There are many notions of complexity and volatility in the literature. In our research we define:
- problem complexity as related to the presence of many interconnected parts
- problem volatility as related to the likelihood of rapid change
To which extent do these definitions make sense to you? What sort of complexity and volatility do you encounter more often in your PM work? Can you give me examples?

Long-answer text

Should you know that you deal with a complex problem, how would you set up your project to cope with that? Why? Can you give me specific examples?

Long-answer text

Should you know that you deal with a volatile problem, how would you set up your project to cope with that? Why? Can you give me specific examples?

Long-answer text
<table>
<thead>
<tr>
<th>Question</th>
<th>Long-answer text</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you set up your project when you need to deal with both complexity and volatility?</td>
<td></td>
</tr>
<tr>
<td>Are there any approaches/tools/methods you currently use to help you identify problem complexity and/or volatility characteristics and to parameterise your projects?</td>
<td></td>
</tr>
<tr>
<td>If not, what sort of tools/methods would be of value to you as a practitioner?</td>
<td></td>
</tr>
<tr>
<td>We are coming to the end of the interview, is there anything else that you would like to comment on?</td>
<td></td>
</tr>
</tbody>
</table>

**Figure B.19:** Screenshots from the interview developed through Google Forms - part 4

<table>
<thead>
<tr>
<th>Question</th>
<th>Long-answer text</th>
</tr>
</thead>
<tbody>
<tr>
<td>I still have a number of interviews to conduct. In the next few months I will analyse the results and write my report. Would you be interested in receiving a copy?</td>
<td></td>
</tr>
</tbody>
</table>

**Figure B.20:** Screenshots from the interview developed through Google Forms - part 5
Appendix C

Case study: New company acquisition problem

C.1 Overview of the project

C.1.1 PPP characterisation

Due to the complexity of the problem structure, it is not possible to represent the PPP of the complete problem tree. But, as already mentioned in the retrospective case study[4.3], the information captured in the worksheet enables to reconstruct the problem steps and do partial representations of the PPP.

Similarly, in the figure, we have used the prefix PE as a shorthand for Problem Exploration and SE for Solution Exploration: for instance the problem exploration of problem P1 is indicated as PEP1. The figure also indicates where validation failed, with a red cross in the corresponding validation diamond, highlighting where the process had to backtrack and resources were wasted.

C.2 Problem steps description and control comparison

C.2.1 Organisational and project problem steps
Appendix C. Case study: New company acquisition problem

Figure C.1: PPP model of the problem steps
### Table C.1: Description of problem steps

<table>
<thead>
<tr>
<th>Organi-sa-tional problem</th>
<th>Project Problem (project prob. only)</th>
<th>Status prob. valid.</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status sol. valid.</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>√ Board</td>
<td>To understand how Company A should grow</td>
<td>Target market sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
</tr>
<tr>
<td>P1</td>
<td>√ Board</td>
<td>To acquire and integrate Company C</td>
<td>Companies A, B and C, their infrastructure, and business and international context</td>
<td>√</td>
<td>Board</td>
<td>Combination of sub-problems solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>√ Board</td>
<td>To acquire Company C at the right conditions</td>
<td>Companies A, B, acquisition laws</td>
<td>√</td>
<td>Board</td>
<td>Combination of sub-problems solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP2</td>
<td>Starting</td>
<td>Set up a project to collect information about the value of Company C and the feasibility to integrate it to A</td>
<td>Companies A and C</td>
<td>√</td>
<td>Board, Head of region, Head of company C, Heads of each function, Heads of each division</td>
<td>Merge &amp; Acquisition Project set up with a team lead by external consultants</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued on next page
## Table C.1 – continued from previous page

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Phase (project prob. only)</th>
<th>Status prob. valid.</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status sol. valid</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP2.1</td>
<td>Organising and preparing</td>
<td>Board</td>
<td>Plan the steps to collect the information and the internal resources needed</td>
<td>Company A, consultancy</td>
<td>✓</td>
<td>Board, heads of regions, divisions and functions</td>
<td>Detailed project plan set up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP2.2</td>
<td>Carrying out the work</td>
<td>consultants, team representing functions</td>
<td>Collect information related to value of Company and operation model</td>
<td>Companies A, B and C, market</td>
<td>✓</td>
<td>Board, heads of regions, divisions and functions</td>
<td>Information collected through questionnaires and on-site visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP2.3</td>
<td>Carrying out the work</td>
<td>consultants, team representing functions</td>
<td>Agree internally on offer to Company B</td>
<td>Companies A, B and C, market</td>
<td>✓</td>
<td>Board, team representing functions</td>
<td>Letter of intent drawn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP2.4</td>
<td>Closing</td>
<td>consultants, team representing functions</td>
<td>Close deal with Company B to buy Company C</td>
<td>Companies A, B and C, market</td>
<td>✓</td>
<td>Board, board company B</td>
<td>Contract signed with company B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>✓</td>
<td>Board</td>
<td>To integrate Company A and Company C organisational structures</td>
<td>Companies A and C</td>
<td>✓</td>
<td>Board</td>
<td>Combination of sub-problems solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3.1</td>
<td>✓</td>
<td>Board, heads of regions, divisions and functions</td>
<td>To define organisational structure for Company C</td>
<td>Companies A and C</td>
<td>✓</td>
<td>Board, heads of regions, divisions and functions</td>
<td>Organigram for company C defined with reporting lines to 2 divisions, region and functions (3D Matrix)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued on next page
<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Phase (project prob. only)</th>
<th>Status prob. valid.</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status sol. valid</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3.2</td>
<td></td>
<td>✓</td>
<td>Board, heads of regions, divisions and functions</td>
<td>To find candidates to fill organisational structure</td>
<td>Companies A and C</td>
<td>✓</td>
<td>Board, heads of regions, divisions and functions</td>
<td>Organigram filled with candidates</td>
<td></td>
</tr>
<tr>
<td>P3.3</td>
<td></td>
<td>✓</td>
<td>Candidates, company C</td>
<td>To allow candidate staff members from abroad to start working in C</td>
<td>Companies A and C, migration regulations</td>
<td>X</td>
<td>Candidates migration authorities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3.2.B</td>
<td></td>
<td>✓</td>
<td>Board, heads of regions, divisions and functions</td>
<td>To find new candidates to fill organisational structure</td>
<td>Companies A and C</td>
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<td>Organigram filled with new candidates</td>
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<td></td>
<td>✓</td>
<td>Candidates, company C</td>
<td>To allow new candidates staff members from abroad to start working in C</td>
<td>Companies A and C, migration regulations</td>
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<td>New candidates, migrations activities</td>
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<td>Board</td>
<td>To integrate Company A and Company C business processes</td>
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<td>To define and implement business plan for division 2</td>
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<td>Board, Head of region, Head of company C, Heads of each function, heads of each division</td>
<td>To define and implement business plan for all functions</td>
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<td>Company A, Company C, Market, regional, local and divisional business plans, existing processes and applications in C</td>
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<td>To define business plan for all functions except IT processes and applications</td>
<td>Company A, Company C, Market, regional, local and divisional business plans, existing processes and applications in C</td>
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<td>Head of functions, board ✓</td>
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<td>To implement business plan for all functions except IT</td>
<td>Companies A and C</td>
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<td>Head of functions, Head of company C</td>
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<td>Board, Head of region, Head of company C, Heads of each function, heads of each division</td>
<td>To define business plan for IT processes and applications</td>
<td>Companies A and C, contract</td>
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<td>Business plan for IT processes and applications defined and approved</td>
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<td><strong>PP9</strong></td>
<td>Starting</td>
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<td>Board, Head of region, Head of company C, Heads of each function, heads of each division</td>
<td>To explore viability and obtain approval of proposed business plan for IT processes and applications consisting in the integration of Company C in Company’s A processes and applications within time-line agreed in contract</td>
<td>Companies A and C, contract</td>
<td>Head of region, head of company C</td>
<td>Combination of sub-problems solutions</td>
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<td>PP9.1</td>
<td>Organising and preparing</td>
<td>Board, Head of IT, Head of company C, Process Owners</td>
<td>To get a comprehensive understanding of existing processes and applications in Company C</td>
<td>Company A, Company C, existing processes and applications in C</td>
<td>✓</td>
<td>Program Manager, Head of IT, Head of company C, Process Owners</td>
<td>Workshop on site to get a comprehensive understanding of existing processes and applications in company C executed</td>
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<td>PP9.2</td>
<td>Organising and preparing</td>
<td>Program Manager, Head of company C, Process Owners</td>
<td>To identify IT processes and applications to be adapted in A to in order integrate C (work packages)</td>
<td>Company A, Company C, existing processes and applications in C and A</td>
<td>✓</td>
<td>Process owners, Program manager</td>
<td>Second workshop at company A with participation of specialists to identify work packages performed</td>
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<td>PP9.3</td>
<td>Carrying out the work</td>
<td>Process owners, Program manager</td>
<td>To identify work packages, estimate scope and effort</td>
<td>✓</td>
<td>Process owners, Program manager, Process Experts</td>
<td>Detailed project plan with differentiated implementation strategy differential handling based on technical complexity in solution created</td>
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<td>Carrying out the work</td>
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<td>Process owners, Program manager, Process Experts</td>
<td>To define scope, effort estimation and possible timeline WP1 (system customisation)</td>
<td>Company A, Company C, identified work packages</td>
<td>√</td>
<td>Program Manager, Head of company C, Process Owners</td>
<td>Scope, effort estimation and possible timeline WP1 (system customisation) defined</td>
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<td>Carrying out the work</td>
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<td>Process Experts</td>
<td>To define scope, effort estimation and possible timeline WP2 (data migration)</td>
<td>Company A, Company C, identified work packages</td>
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<td>Program Manager, Head of company C, Process Owners</td>
<td>Scope, effort estimation and possible timeline WP2 (data migration) defined</td>
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<td>To define scope, effort estimation and possible timeline WP3 (Customer service)</td>
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<td>√</td>
<td>Program Manager, Head of company C, Process Owners</td>
<td>Scope, effort estimation and possible timeline WP3 (Customer service) defined</td>
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<td>To define scope, effort estimation and possible timeline WP4 (eCommerce)</td>
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<td>To define scope, effort estimation and possible timeline WP5 (PLM)</td>
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<td>To define scope, effort estimation and possible timeline WP6 (sales support)</td>
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<td>Program Manager, Head of company C, Process Owners</td>
<td>Current solution in use in company C could be kept, WP6 postponed with no defined implementation date</td>
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<td>To create a detailed project plan to adapt processes in A to be implemented in C</td>
<td>Company A, Company C, identified GAPs between existing processes in C and A</td>
<td>✓</td>
<td>Board, Head of IT, Program Manager, Head of company C, Process Owners</td>
<td>Detailed project plan with differentiated implementation strategy differential handling based on technical complexity in solution created</td>
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<td>To agree on scope and effort work packages to be implemented within the contract timeline and on which to be postponed based on the plan</td>
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<td>To integrate Company C in Company’s A processes and applications within timeline agreed in contract</td>
<td>Company A, Company C, detailed project plan</td>
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<td>To implement WPI (system customising with no tax requirements)</td>
<td>Company A, Company C</td>
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<td>Company A, Company C, Tax requirements, Tax solutions for country Y</td>
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<td>Project team</td>
<td>To implement WP3 based on technical solution Z</td>
<td>Company A, Company C, technical solutions for WP3</td>
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<td>Project team, Company C</td>
<td>Prototype implemented for WP3 based on technical solution Z</td>
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<td>Project team</td>
<td>To implement WP3 based on prototype</td>
<td>Company A, Company C, Prototype WP3</td>
<td>√</td>
<td>Project team, Company C</td>
<td>WP3 implemented</td>
</tr>
<tr>
<td>PP14</td>
<td>Carrying out the work</td>
<td>Project team</td>
<td>√</td>
<td>Project team</td>
<td>To implement WP4 based on technical solution A</td>
<td>Company A, Company C, technical solutions for WP4, Company C web applications</td>
<td>√</td>
<td>Project team, Company C</td>
<td>WP4 implemented</td>
</tr>
<tr>
<td>PP14.1</td>
<td>Carrying out the work</td>
<td>Project team, Head of company C</td>
<td>√</td>
<td>Project team</td>
<td>To implement WP4 again to satisfy new customer requirements</td>
<td>Company A, Company C, new scope WP4</td>
<td>√</td>
<td>Project team, Company C</td>
<td>WP4 implemented</td>
</tr>
<tr>
<td>PP15</td>
<td>Change, re-work</td>
<td>Project team</td>
<td>√</td>
<td>Project team</td>
<td>To implement WP5 based on technical solution B</td>
<td>Company A, Company C, technical solutions for WP5, current Company C solution for WP5</td>
<td>X</td>
<td>Project teamX, Company C</td>
<td>WP5 could not be implemented based on technical solution B</td>
</tr>
<tr>
<td>PP15B</td>
<td>Change, re-work</td>
<td>Project team</td>
<td>√</td>
<td>Project team</td>
<td>To implement WP5 based on technical solution C</td>
<td>Company A, Company C, current Company C solution for WP5, technical solutions for WP5</td>
<td>X</td>
<td>Project teamX, Company C</td>
<td>WP5 could not be implemented based on technical solution C</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Phase (project prob. only)</th>
<th>Status prob. valid.</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status sol. valid</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP15C</td>
<td>Carrying out the work</td>
<td>Project team</td>
<td>√</td>
<td>Project team</td>
<td>To implement WP5 based on technical solution D</td>
<td>Company A, Company C, electrical Market, current Company C solution for WP5, technical solutions for WP5</td>
<td>√</td>
<td>Project team, Company C</td>
<td>WP5 implemented</td>
</tr>
<tr>
<td>PP16</td>
<td>Carrying out the work</td>
<td>Board, Head of IT, Program Manager, Head of company C, Process Owners</td>
<td>√</td>
<td>Project team, Head of company CX</td>
<td>To perform Integration and final acceptance tests</td>
<td></td>
<td></td>
<td>Project team, Company C</td>
<td>Combination of sub-problems solutions</td>
</tr>
<tr>
<td>PP16.1</td>
<td>Carrying out the work</td>
<td>Project team, Head of company CX</td>
<td>√</td>
<td>Project team, Head of company CX</td>
<td>To perform integration test for WP1 and WP2 WPs</td>
<td>Company A, Company C, already implemented WPs, new customer requirement for WP4</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP16.2</td>
<td>Carrying out the work</td>
<td>√</td>
<td>Project team, Head of company CX</td>
<td>To perform final acceptance tests for all WPs</td>
<td>Company A, Company C, already implemented WPs, new customer requirement for WP4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

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### C.3 Description of recommended and actual controls

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Phase (project prob. only)</th>
<th>Status prob. valid.</th>
<th>Problem validators</th>
<th>Need</th>
<th>Context</th>
<th>Status sol. valid</th>
<th>Solution validators</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP16.2B</td>
<td>Carrying out the work</td>
<td>✓</td>
<td>Board, Head of IT, Program Manager, Head of company C, Process Owners</td>
<td>To perform final acceptance tests for all WPs except WP4</td>
<td>Company A, Company C, already implemented WPs</td>
<td>✓</td>
<td>Project team, Company C</td>
<td>Final acceptance test performed successfully (P26)</td>
<td></td>
</tr>
<tr>
<td>PP17</td>
<td>Carrying out the work</td>
<td>✓</td>
<td>Project team, Company C</td>
<td>To execute activities in cut over plan in order to go live</td>
<td>Company A, Company C, implemented WPs, cutover plan</td>
<td>✓</td>
<td>Project team, Company C</td>
<td>Go live executed</td>
<td></td>
</tr>
<tr>
<td>PP18</td>
<td>Closing</td>
<td>✓</td>
<td>Project team, Company C</td>
<td>To complete activities collected in open issues list and change of location</td>
<td>Company A, Company C, implemented WPs, open issue list, contractual requirement to change location</td>
<td>✓</td>
<td>Project team, Company C</td>
<td>Activities collected in open issues list finalised, including change of location</td>
<td></td>
</tr>
<tr>
<td>PP18.1</td>
<td>Closing</td>
<td>✓</td>
<td>Project team, Company C</td>
<td>To ensure training by regional IT to train any new employee joining company C</td>
<td>C: Company A, Company C, implemented WPs, Regional IT structure</td>
<td>✓</td>
<td>Project team, regional IT</td>
<td>Regional IT enabled to train new company C employees</td>
<td></td>
</tr>
</tbody>
</table>

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### Table C.2: Description of complexity and volatility, recommended and actual controls

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<tr>
<th>Organisational problem</th>
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<th>Complexity/volatility</th>
<th>Tangling</th>
<th>Control according to model</th>
<th>Actual controls applied</th>
<th>Differences</th>
<th>Actual project outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>P1</td>
<td>n/a</td>
<td>Technical, social and knowledge complexity-Knowledge volatility (changing market)</td>
<td>Contract signed in P2 will be constraint in P3 and P4. P3 is parallel to P4 but needs to be solved, so that P4 can be solved, because the organisation in place in P3 will be the validators for P4. Parallelity in order to gain speed and react to the changing market.</td>
<td>Decomposition into subproblems with minimal interdependency</td>
<td>Short and frequent exploration cycles</td>
<td>None</td>
<td>Knowledge complexity and volatility was not systematically addressed neither at that point nor later. The underestimation of technical complexity because of lack of knowledge led to unrest during the whole problem solving chain.</td>
</tr>
<tr>
<td>Organisational problem</td>
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<td>------------------------</td>
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</tr>
<tr>
<td>P2</td>
<td>PP2</td>
<td>Knowledge complexity: (lots of information to be discovered and complicated communication as result of the signed contract) Social complexity: (many organisational characteristics Company A, also team representing many organisational units may follow own goals or own knowledge) Social volatility, as the team in charge or the negotiations is temporary and will not be in charge of implementation.</td>
<td>Contract signed in P2 was a constraint in P3 and P4 being source of knowledge complexity afterwards, and knowledge volatility because of the negotiated short timeline Social volatility in the solution was responsible for overseen clauses in the contract, affecting problem 5.2 and P20</td>
<td>Knowledge complexity: Short and frequent exploration cycles in problem space Team expertise and / or short and frequent learning cycles Social complexity: Stakeholder management Social volatility: Explicit documentation</td>
<td>Team expertise and short and frequent learning cycles Stakeholder management</td>
<td>Short and frequent exploration cycles in problem space not conducted Explicit documentation not applied</td>
<td>Negative: Time negotiated for the carve out was too short, putting time pressure to the implementation. Unclear contractual agreements lead to law suits. Information went lost, and needed to be collected again, lead to delays and to miss important information for further stages of project</td>
</tr>
</tbody>
</table>
### Table C.2 – continued from previous page

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>P3</td>
<td>n/a</td>
<td>Knowledge complexity because of regulations, social complexity, because of company A org. structure as 3D matrix: divisional, functional, regional, social volatility because of changes in organisation</td>
<td>n/a</td>
<td>Problem exploration to uncover knowledge complexity and social volatility. Social volatility: Incentive team to stay until end of implementation Stakeholder substitution Knowledge complexity: Team expertise</td>
<td>Stakeholder management</td>
<td>Social volatility and knowledge complexity neither detected nor controlled</td>
<td>Negative: Unknown regulations and lack of incentive to stay lead to fail to solve the problem step. No responsible contact person was available for key decisions, leading to delays. High rotation of local managers due to large number of expats.</td>
</tr>
<tr>
<td>P3.1</td>
<td>n/a</td>
<td>Social complexity, because of company A org. structure as 3D matrix: divisional, functional, regional</td>
<td>n/a</td>
<td>See P3</td>
<td>See P3</td>
<td>See P3</td>
<td>n/a</td>
</tr>
<tr>
<td>P3.2</td>
<td>n/a</td>
<td>Social complexity (due to the complex organisation of A transposed to C)</td>
<td>n/a</td>
<td>See P3</td>
<td>See P3</td>
<td>See P3</td>
<td>n/a</td>
</tr>
<tr>
<td>P3.3</td>
<td>n/a</td>
<td>Social volatility, knowledge complexity</td>
<td>n/a</td>
<td>See P3</td>
<td>See P3</td>
<td>See P3</td>
<td>n/a</td>
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<tbody>
<tr>
<td>P3.2.B</td>
<td>n/a</td>
<td>Social complexity (due to the complex organisation of A transposed to C)</td>
<td>n/a</td>
<td>See P3</td>
<td>See P3</td>
<td>See P3</td>
<td>n/a</td>
</tr>
<tr>
<td>P3.3.B</td>
<td>n/a</td>
<td>Social volatility, knowledge complexity</td>
<td>n/a</td>
<td>See P3</td>
<td>See P3</td>
<td>See P3</td>
<td>n/a</td>
</tr>
<tr>
<td>P4</td>
<td>n/a</td>
<td>Social complexity, because of company A org. structure as 3D matrix. Technical complexity with extreme tangling. Knowledge complexity and volatility because of the negotiated conditions in P2.</td>
<td>Shared phenomena: business plans for each org. unit are constraints for the others, company C employees are shared resources for all implementations.</td>
<td>Social complexity: Stakeholder management Technical complexity Scope simplification and/or decomposition into subproblems with minimal interdependency Knowledge volatility Scope simplification or Short and frequent exploration cycles Knowledge complexity Weakly through decomposition into subproblems with minimal interdependency</td>
<td>Decomposition into subproblems with minimal dependencies Stakeholder management</td>
<td>Not necessarily knowledge complexity and volatility was controlled in each of the subproblems.</td>
<td>Partially positive: Validators were too high in the organisation and all issues were escalated and decisions delayed. Issues due to the partially uncontrolled knowledge complexity and volatility in the subproblems</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Organisational problem</th>
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<tbody>
<tr>
<td>P5</td>
<td>n/a</td>
<td>Social complexity (org. structure company C and org. structure company A), knowledge complexity and volatility (contract signed with B and electrical market), social volatility (see P3). Technical complexity.</td>
<td>Effect from the social volatility in the solution of P3 and the knowledge complexity and volatility from PP2.1 and PP2.4</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
<td>Partially negative: Many difficulties. Example: one contractual issue overseen (P2), led to a non planned urgent relocation of the company (P20.1)</td>
</tr>
<tr>
<td>P5.1</td>
<td>n/a</td>
<td>See P5, technical complexity reduced due to previous problem decomposition.</td>
<td>n/a</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
<td>n/a</td>
</tr>
<tr>
<td>P5.2</td>
<td>n/a</td>
<td>Knowledge volatility inherited from contract signed at P2</td>
<td>n/a</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
<td>n/a</td>
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<tr>
<td>P5.3</td>
<td>n/a</td>
<td>Social volatility because of employees leaving the company</td>
<td>n/a</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
<td>n/a</td>
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<tr>
<th>Organisational problem</th>
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<th>Complexity/ volatility</th>
<th>Tangling</th>
<th>Control according to model</th>
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<th>Differences</th>
<th>Actual project outcome</th>
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<tbody>
<tr>
<td>P6</td>
<td>n/a</td>
<td>Social complexity (org. structure company C and org. structure company A), knowledge complexity and volatility (contract signed with B and electrical market), social volatility (see P3). Technical complexity.</td>
<td>Effect from the social volatility in the solution of P3 and the knowledge complexity and volatility from PP2.1 and PP2.4</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
<td>Partially negative: Many difficulties. Example: one change in a customer requirement, led to a change of business plan and further implementation of a WP (P19)</td>
</tr>
<tr>
<td>P6.1</td>
<td>n/a</td>
<td>See P6, technical complexity reduced due to previous problem decomposition.</td>
<td>n/a</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
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<td>P6.2</td>
<td>n/a</td>
<td>See P6, technical complexity reduced due to previous problem decomposition.</td>
<td>n/a</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
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<tr>
<td>P6.3</td>
<td>n/a</td>
<td>See P6, technical complexity reduced due to previous problem decomposition.</td>
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<td>see P4</td>
<td>see P4</td>
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<th>Project Problem</th>
<th>Complexity/ volatility</th>
<th>Tangling</th>
<th>Control according to model</th>
<th>Actual controls applied</th>
<th>Differences</th>
<th>Actual project outcome</th>
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<tbody>
<tr>
<td>P7</td>
<td>n/a</td>
<td>Social complexity (org. structure company C and org. structure company A), knowledge complexity and volatility (contract signed with B and electrical market), social volatility (see P3). Technical complexity.</td>
<td>Effect from the social volatility in the solution of P3 and the knowledge complexity and volatility from P2</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
<td>n/a</td>
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<tr>
<td>P7.1</td>
<td>n/a</td>
<td>See P7, technical complexity reduced due to previous problem decomposition.</td>
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<td>see P4</td>
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<td>P7.2</td>
<td>n/a</td>
<td>See P7, technical complexity reduced due to previous problem decomposition.</td>
<td>n/a</td>
<td>see P4</td>
<td>see P4</td>
<td>see P4</td>
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<th>Organisational problem</th>
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</tr>
</thead>
<tbody>
<tr>
<td>P8</td>
<td>n/a</td>
<td>Social complexity (org. structure company C and org. structure company A), knowledge complexity and volatility (contract signed with B and electrical market), social volatility (see P3). Technical complexity.</td>
<td>Effect from the social volatility in the solution of P3 and the knowledge complexity and volatility from P2 see P4</td>
<td>see P4</td>
<td>see P4</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>P8.1</td>
<td>n/a</td>
<td>See P8, technical complexity reduced due to previous problem decomposition.</td>
<td>n/a</td>
<td>See P8</td>
<td>See P8</td>
<td>See P8</td>
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</tr>
<tr>
<td>P8.1.B</td>
<td>n/a</td>
<td>See P8, technical complexity reduced due to previous problem decomposition.</td>
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<td>See P8</td>
<td>See P8</td>
<td>See P8</td>
<td>n/a</td>
</tr>
<tr>
<td>P8.2</td>
<td>n/a</td>
<td>See P8, technical complexity reduced due to previous problem decomposition.</td>
<td>n/a</td>
<td>See P8</td>
<td>See P8</td>
<td>See P8</td>
<td>n/a</td>
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</tr>
</thead>
<tbody>
<tr>
<td>P9</td>
<td>PP9</td>
<td>Social complexity (org. structure company C and org. structure company A), knowledge complexity and volatility (contract signed with B and electrical market)</td>
<td>Waste of resources, loss of information as not the same team involved in further activities. Wrong scope, wrong resources estimation due to conflict of requirements or wrong evaluated technical possibilities. Not to find any feasible solution within the contract time-line due to the technical complexity and to the goals conflict coming from the social complexity in the need.</td>
<td>Social complexity: Stakeholder management combined with stakeholder substitution, knowledge complexity: frequent explorations cycles</td>
<td>Learning achieved through short and frequent problem exploration and team expertise. Stakeholder management with stakeholder substitution helped to control social complexity</td>
<td>none</td>
<td>Partially positive: Time was saved, implementation team failed to come back to the original documentation and repeated the process afterwards during the implementation. Difficulties to manage certain stakeholder brought difficulties to the project team during implementation.</td>
</tr>
</tbody>
</table>

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Table C.2 – continued from previous page

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</tr>
</thead>
<tbody>
<tr>
<td><strong>P10</strong></td>
<td>PP10</td>
<td>Knowledge complexity (reduced due to P9), technical complexity. Social complexity (organisational structure company C and organisational structure company A). Knowledge volatility in the context inherited from the contract signed in P2 but reduced due to timeline adjusted in P9, social volatility inherited from P3</td>
<td>n/a</td>
<td>Social complexity: Stakeholder management Technical and knowledge complexity and knowledge volatility: Addressed with decomposition in subproblems with minimal interdependency (through P11 to P18), scope simplification and short learning problem exploration in P9.</td>
<td>Social complexity: Stakeholder management Formal quality gates Technical and knowledge complexity and knowledge volatility: Addressed with decomposition in subproblems with minimal interdependency, scope simplification and short learning problem exploration in P9 through PP11 to PP19</td>
<td>Additionally formal quality gates due to the difficulty to manage certain stakeholder</td>
<td>Positive: issues with stakeholder management.</td>
</tr>
<tr>
<td><strong>P11</strong></td>
<td>PP11</td>
<td>Knowledge and technical complexity.</td>
<td>n/a</td>
<td>Knowledge complexity: Team expertise Technical complexity: Decomposition into work packages with minimal interdependency</td>
<td>Technical complexity: Decomposition into work packages with minimal interdependency After failure: Team expertise</td>
<td>Originally no control for knowledge complexity applied.</td>
<td>Partially positive: Missing control for knowledge complexity lead to failure of P11. Finally after all experts on board in person, solution implemented with no issues</td>
</tr>
</tbody>
</table>

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<tbody>
<tr>
<td>P12*</td>
<td>PP12</td>
<td>Technical complexity</td>
<td>n/a</td>
<td>Technical complexity: Scope simplification Decomposition into work packages with minimal interdependency Up front plans Strict governance and accountability (risk transfer)</td>
<td>Technical complexity: Scope simplification Decomposition into work packages with minimal interdependency Up front plans Strict governance and accountability (risk transfer)</td>
<td>none</td>
<td>Positive: Known task, proved methodology</td>
</tr>
<tr>
<td>P13*</td>
<td>PP13</td>
<td>Social, technical and knowledge complexity</td>
<td>n/a</td>
<td>Social complexity: Stakeholder management, with stakeholder substitution Knowledge complexity: Prototyping Team expertise Technical complexity: Decomposition into work packages with minimal interdependency Scope simplification</td>
<td>Social complexity: Stakeholder management, with stakeholder substitution Knowledge complexity: Prototyping Team expertise Technical complexity: Decomposition into work packages with minimal interdependency</td>
<td>none</td>
<td>Positive: Solution was successfully implemented and used as a prototype for the whole company A afterwards.</td>
</tr>
</tbody>
</table>

Continued on next page
Table C.2 – continued from previous page

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Complexity/volatility</th>
<th>Tangling</th>
<th>Control according to model</th>
<th>Actual controls applied</th>
<th>Differences</th>
<th>Actual project outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>P14*</td>
<td>PP14</td>
<td>In spite of scope reduc-</td>
<td>Problem was back-</td>
<td>Technical complexity: Scope</td>
<td>Technical complexity: Scope</td>
<td>none</td>
<td>Partially positive: Due to the unknown social volatility, changed technical solution was partially not available on time before go live</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tion in P9.3.4 still knowledge and technical complexity. Social volatility manifested afterwards</td>
<td>tracked due to changes in P6.2.</td>
<td>simplification Knowledge complexity: Team expertise</td>
<td>simplification Knowledge complexity: Team expertise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P14.1*</td>
<td>PP14.1</td>
<td>Knowledge and Technical complexity, social volatility</td>
<td>n/a</td>
<td>Technical complexity: Scope simplification Knowledge complexity: Team expertise Social volatility: Stakeholder required to identify and agree priorities first or frequent development and feedback cycle (also weak mitigation for technical complexity)</td>
<td>Technical complexity: Scope simplification Knowledge complexity: Team expertise Social volatility: Stakeholder required to identify and agree priorities first instead of short and frequent development and feedback cycles.</td>
<td>Combination of scope simplification and stakeholder required to identify and agree priorities firstinstead of short and frequent development and feedback cycles.</td>
<td>Partially positive: Decision to change business model with one of the key customers required redesign of interface. Customer could be satisfied in the end but rest of interface did not work properly and needed to be repaired afterwards.</td>
</tr>
</tbody>
</table>

Continued on next page
## Appendix C. Case study: New company acquisition problem

Table C.2 – continued from previous page

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Complexity / volatility</th>
<th>Tangling</th>
<th>Control according to model</th>
<th>Actual controls applied</th>
<th>Differences</th>
<th>Actual project outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>P15</td>
<td>PP15</td>
<td>Knowledge, technical and social complexity (need to retrain users in a new key application).</td>
<td>n/a</td>
<td>Social complexity: Stakeholder management Technical complexity: Scope simplification Knowledge complexity: Team expertise</td>
<td>Social complexity: Stakeholder management Technical complexity: Scope simplification Team expertise was recognised as a control but not applied due to lack of experts on the topic.</td>
<td>Team expertise was tested, resistance in IT to add new application to the system landscape, no business clear statement because of missing manager (see P3). Interface issues were solved after finding an expert, no negative impact on the business. Solution to be replaced in a second step.</td>
<td>Partially positive: Several technical solutions were tested, resistance in IT to add new application to the system landscape, no business clear statement because of missing manager (see P3). Interface issues were solved after finding an expert, no negative impact on the business. Solution to be replaced in a second step.</td>
</tr>
</tbody>
</table>

Continued on next page
Table C.2 – continued from previous page

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Complexity/volatility</th>
<th>Tangling</th>
<th>Control according to model</th>
<th>Actual controls applied</th>
<th>Differences</th>
<th>Actual project outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>P16*</td>
<td>PP16</td>
<td>Technical complexity</td>
<td>n/a</td>
<td>Technical complexity:Scope simplification Decomposition into work packages with minimal inter-dependency Up front plans Strict governance and accountability (risk transfer)</td>
<td>Technical complexity:Scope simplification Decomposition into work packages with minimal inter-dependency Up front plans Strict governance and accountability (risk transfer)</td>
<td>none</td>
<td>Positive: Known task, proved methodology</td>
</tr>
<tr>
<td>P17*</td>
<td>PP17</td>
<td>Technical complexity</td>
<td>n/a</td>
<td>Technical complexity:Scope simplification Decomposition into work packages with minimal inter-dependency Up front plans Strict governance and accountability (risk transfer)</td>
<td>Technical complexity:Scope simplification Decomposition into work packages with minimal inter-dependency Up front plans Strict governance and accountability (risk transfer)</td>
<td>None</td>
<td>Positive: Known task, proved methodology</td>
</tr>
</tbody>
</table>

Continued on next page
### Table C.2 – continued from previous page

<table>
<thead>
<tr>
<th>Organisational problem</th>
<th>Project Problem</th>
<th>Complexity/volatility</th>
<th>Tangling</th>
<th>Control according to model</th>
<th>Actual controls applied</th>
<th>Differences</th>
<th>Actual project outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>P18*</td>
<td>P18</td>
<td>Social volatility coming from changes in P5.2, technical complexity</td>
<td>Problem was unsolved due to new need from changes in P5.2.</td>
<td>Technical complexity: Scope simplification Decomposition into work packages with minimal interdependency Up front plans Strict governance and accountability (risk transfer) Social volatility: Strict change control</td>
<td>Technical complexity: Scope simplification Decomposition into work packages with minimal interdependency Up front plans Strict governance and accountability (risk transfer)</td>
<td>The problem validator did not accept to control the changes, therefore the problem failed and needed to be redefined.</td>
<td>Partially positive: high expenditure to adapt to changes</td>
</tr>
<tr>
<td>P18B*</td>
<td>P18B</td>
<td>Technical complexity</td>
<td>Problem was backtracked due to changes in P5.2 (people leaving the company)</td>
<td>Technical complexity: Scope simplification</td>
<td>Scope simplification</td>
<td>none</td>
<td>See P18</td>
</tr>
<tr>
<td>P18.1*</td>
<td>P18.1</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Partially positive: changing organisation continued being a source of volatility after implementation</td>
</tr>
</tbody>
</table>

### C.3.1 References for the application of the method

Figure 7 displays the references used in the representation of the problem tree in the case study in Chapter 7.
Appendix C. Case study: New company acquisition problem

References

- **P1**: Organisational problem step
- **P2**: Starting phase
- **PP1**: Organising and preparing phase
  - Approved deliverables of the organising and preparing phase (e.g., project plan)
- **PP3**: Carrying out the work phase
  - Approved deliverables of the carrying out the work phase (e.g., project deliverables, monitoring data)
- **PP4.5**: Closing phase
  - Approved deliverables of the closing phase (e.g., project documentation)
  - Problem not validated successfully, either at the need (N) or solution (S)
  - Problem originally validated successfully but then backtracked due to changes in other problems
- Problem chain
- Problems influencing each other due to the sharing of phenomena and/or inheritance of characteristics of complexity and/or volatility
- Interrupted problem chain for abbreviation
- Tightly iterative architecture in the project problem space

Risks arising from:

- **P1**: Complexity or volatility not assessed
  - Social volatility
  - Social complexity
- Technical volatility
- Technical complexity
- Knowledge volatility
- Knowledge complexity

**Figure C.2**: References used in the representation of the problem tree according to our method
Appendix D

Practitioners’ evaluation of the method

D.1 Documents used to support the evaluation process

D.1.1 Information sent to participants

As you know, as part of my research, I developed a method for the systematic parametrisation of project management processes in the face of complexity and volatility.

The objective of this current piece of research is to evaluate the method in terms of its usability and applicability of the recommendations provided by it through interviews with project managers that I am planning to conduct during the first 2 weeks of April.

If you agree to participate, in the first part of the interview, you will be requested to describe a complex project you recently worked on which will be used to test the method retroactively on it.

Then you will be guided through the application of the method and obtain some recommendations about the parametrisation of the project.

Finally, you will be requested to share your experience through a short questionnaire.

I expect the whole interview, including the questionnaire, to have a duration between 30 minutes and one hour.

Your answers will be used for academic research purposes only, and your participation will be treated in strict confidence following the Data Protection Act 2018 (GDPR). No personal information will be collected in this questionnaire. You won’t be identified in any research report which may be produced. The data collected through this questionnaire will be stored on my PC and destroyed after 3 years from completion of this research.

This research has been reviewed by, and received a favourable opinion, from the OU Human Research Ethics Committee - HREC reference number: 2008 (http://www.open.ac.uk/research/ethics/)

To schedule the interview, please send me a time slot that is suitable for you for me to set up the teams’ session.

**Figure D.1:** Screenshot from the invitation to participate in the interview

D.1.2 Instructions for the application of the method

D.1.2.1 Preamble displayed to the interviewees

We understand projects as problem solving activities. We distinguish between the organisational problem, which requires addressing a specific organisational need, and the project problem, which requires organising the project to deliver the solution to the organisational problem. Therefore to start applying the method, we need to understand the problem that the project is set up to solve. With that purpose, we explore the problem so as to understand the characteristics
of complexity and volatility and the relationship between different components of the problem such as: stakeholders, technical components and knowledge.

In this exercise we will identify the risk related to complexity and volatility and discuss about the mitigations or controls to be applied either to manage the organisational problem or during the project problem (project lifecycle).

Please note that the method provides recommendations for the project managers that do not replace but complements their expert judgement.

**D.1.2.2 Instructions**

1. Please describe the problem which the project was set up to solve

2. Think about the characteristics of the problem and answer the questions with yes or no (see Figure D.2). The risks related to characteristics of complexity and volatility will be revealed.

<table>
<thead>
<tr>
<th>Questions</th>
<th>yes / no</th>
<th>Risk related to:</th>
<th>Organisation al problem</th>
<th>Project lifecycle</th>
<th>Return to instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Would you say the number of stakeholders involved is higher than for the average projects in your organisation?</td>
<td>yes</td>
<td>Social Complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Would you say the diversity of stakeholders involved is higher than for the average projects in your organisation?</td>
<td>yes</td>
<td>Social Complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Would you say that the number and interaction of technical components in higher than the for average projects in your organisation?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you relatively have a lot of knowledge to be discovered at start?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the communication due to the amount or diversity of stakeholders difficult?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the communication due to the amount or diversity of stakeholders difficult?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are goals uncertain due to the lack of knowledge at start?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are stakeholders or requirements expected to change before delivery?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are technical components expected to change or become obsolete before delivery?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you dealing with very new technology?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are regulations or environmental conditions expected to change before delivery?</td>
<td>yes</td>
<td>Knowledge Volatility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you face time criticality of goals due to changing conditions of in the organisation?</td>
<td>yes</td>
<td>Social Volatility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you face time criticality of goals due to changing conditions of in the technology?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you face time criticality of goals due to changing conditions in the environment?</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure D.2:** Question asked to participants to identify the problem’s characteristics of complexity and/or volatility

3. Please click to any of the displayed characteristics to access to the list of recommended controls to be applied to manage the organisational problem (see Figure D.3).

**Figure D.3:** Example of recommended controls to be applied to manage the risks at the organisational problem

(a) Use the filter option in cell B1 to display the controls which are recommended for the characteristics found. A list of the controls to be applied to mitigate risk related to the applicable dimension of complexity or volatility will be displayed.

(b) Please avoid selecting controls which cannot be used simultaneously with another (column L).

(c) Please do an initial selection of at least one control to mitigate each type of risk considering that they can be used in combination with each other and mark them with an ‘x’ in the corresponding cell.
Appendix D. Practitioners’ evaluation of the method

(d) Information about how they control the risks, in which phases are to be applied, which impact they have on budget, scope and schedule and how they influence other types of risk will be displayed.

(e) Decide on the final controls based on the information displayed.

4. Please click to any of the displayed characteristics to access to the list of recommended controls to be applied to manage the project problem (during the project life cycle, see Figure D.4).

![Figure D.4: Example of recommended controls to be applied to manage the risks at the project problem](image)

(a) Use the filter option in cell B1 to display the controls which are recommended for the characteristics found. A list of the controls to be applied to mitigate risk related to the applicable dimension of complexity or volatility will be displayed.

(b) Three types of controls will be revealed:
   - controls in the middle, which are neutral and can be used in combination with all other controls;
   - controls on the left (adaptive), which cannot be used in combination with predictive ones; and
   - controls on the right (predictive), which cannot be used in combination with adaptive ones.

(c) Please do an initial selection of at least one control to mitigate each type of risk considering that they can be used in combination with each other and mark them with an ‘x’ in the corresponding cell.

(d) Information about how they control the risks, in which phases are to be applied, which project management processes are affected (see Figure D.5), which impact they have on budget, scope and schedule and how they influence other types of risk will be displayed.

(e) Decide on the final controls based on the information displayed.

5. Please evaluate your experience with the method and the applicability of the recommendations answering the following questions:

(a) Please comment on the usability of the method

(b) Please comment on the relevance of the questions used as input

(c) Please comment to which extent the recommendations proposed by the method were suitable to the challenges faced by the project

(d) Please give any other additional information related to the method
<table>
<thead>
<tr>
<th>4.1</th>
<th>develop project charter</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1</td>
<td>identify stakeholders</td>
</tr>
<tr>
<td>4.2</td>
<td>develop project management plan</td>
</tr>
<tr>
<td>5.1</td>
<td>plan scope management</td>
</tr>
<tr>
<td>5.2</td>
<td>collect requirements</td>
</tr>
<tr>
<td>5.3</td>
<td>define scope</td>
</tr>
<tr>
<td>5.4</td>
<td>create WBS</td>
</tr>
<tr>
<td>6.1</td>
<td>plan schedule management</td>
</tr>
<tr>
<td>6.2</td>
<td>define activities</td>
</tr>
<tr>
<td>6.3</td>
<td>sequence activities</td>
</tr>
<tr>
<td>6.4</td>
<td>estimate activity durations</td>
</tr>
<tr>
<td>6.5</td>
<td>develop schedule</td>
</tr>
<tr>
<td>7.1</td>
<td>plan cost management</td>
</tr>
<tr>
<td>7.2</td>
<td>estimate costs</td>
</tr>
<tr>
<td>7.3</td>
<td>determine budget</td>
</tr>
<tr>
<td>8.1</td>
<td>plan quality management</td>
</tr>
<tr>
<td>9.1</td>
<td>plan resource management</td>
</tr>
<tr>
<td>9.2</td>
<td>estimate activity resources</td>
</tr>
<tr>
<td>10.1</td>
<td>plan communications management</td>
</tr>
<tr>
<td>11.1</td>
<td>plan risk management</td>
</tr>
<tr>
<td>11.2</td>
<td>identify risks</td>
</tr>
<tr>
<td>11.3</td>
<td>perform qualitative risk analysis</td>
</tr>
<tr>
<td>11.4</td>
<td>perform quantitative risk analysis</td>
</tr>
</tbody>
</table>

**Figure D.5:** Extract of the PM processes according to Project Management Institute (2017a) displayed as additional information in relation to the controls recommended by the method.
Appendix D. Practitioners’ evaluation of the method

D.1.3 Questionnaire used for the method evaluation as displayed in google forms

![Image of questionnaire](image)

**Figure D.6: Section: Introduction**
Appendix D. Practitioners’ evaluation of the method

**Your experience**

How long have you been managing projects?

- [ ] less than a year
- [ ] 1 to 3 years
- [ ] 3 to 5 years
- [ ] 5 to 10 years
- [ ] more than 10 years

In what country do you actually work?

Your answer

Which of the following options best describe your current role?

- [ ] Project manager
- [ ] Program manager
- [ ] Project team member
- [ ] Consultant
- [ ] Other:

6. Which of the following options best describes the main type of projects you have worked on in the past 3 years?

- [ ] Administrative/Management Projects
- [ ] Information Systems (Software) Projects
- [ ] Product and Service Development Projects
- [ ] Infrastructure or Construction Projects
- [ ] Other:

*Figure D.7: Section: your experience*
Appendix D. Practitioners’ evaluation of the method

FIGURE D.8: Section: method evaluation
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